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REPORT OF THE COMMITTEE ON THE PRECAUTIONS TO BE TAKEN TO OBVIATE THE DANGERS THAT MAY ARISE FROM SYSTEMS OF ELECTRIC LIGHTING.

The committee, to whom was referred the question of "the dangers incident to electric lighting, if any, and the means of overcoming them," respectfully report as follows, viz.:

That from a careful consideration of the evidence submitted they believe that the use of electricity as an illuminant, as now generally employed, is not attended with any dangers, either to person or property, that cannot be obviated by the adoption of the precautions hereinafter set forth.

In order that the reasons which give rise to the necessity for these precautions may be the more thoroughly understood by the general public, for whom they are designed, the committee believe that the following statements of the general principles involved in systems of electric lighting as now practised, may not be amiss.

There are two systems of electric lighting now in general use, viz.: the "incandescence system" and the "arc system."

In the "incandescence system" an electrical current, flowing through a thin wire of platinum, or other difficultly fusible metal, or through

a thin filament of carbon, heats it by incandescence to nearly a white heat, by reason of the resistance it offers to the passage of the currents.

In the "arc system" an electrical current flowing from one rod of hard carbon to another, heats the rods sufficiently to cause a stream of carbon vapor to pass between them. This vapor, heated to intense whiteness by the electricity, forms what is known technically as the "voltaic arc."

In the "incandescence system" it is necessary, in order to prevent the rapid destruction of the wire, or carbon filament, to surround it completely by a glass globe or cover from which all the air has been removed. In this system, therefore, external objects cannot come into contact with the source of light.

In the "arc system" it is not necessary to exclude the atmospheric air from contact with the carbons, or electrodes as they are sometimes called. Arc lights are, therefore, burned in the open air. They are generally much brighter than incandescent lights and are, in practice, usually surrounded by a globe of glass, in order to lessen the intensity of the glare. They can, however, be placed in a globe from which all the air has been removed, since the light produced is not dependent on the burning of the carbon electrodes—that is, on their combustion.

The source of the electricity employed in all systems of lighting is the dynamo-electric machine. This machine produces, more cheaply, a current whose properties are similar to the current obtained from the ordinary voltaic battery.

In the dynamo-electric machine, mechanical energy, derived from a steam engine, water wheel, or any other suitable source, is converted directly into electrical current. The change of mechanical into electrical energy is obtained by the motion, past powerful magnets, of a number of coils of insulated wire wrapped on a core of iron. The core so wrapped is called the armature. The armature moves close to the poles of the magnets already referred to, but does not actually touch them. There is, therefore, no friction in the dynamo-electric machine as in the ordinary electrical machine. The attraction of the magnet poles tends to hold the armature in fixed positions. Mechanical power is required to move it out of such positions, and when so exerted is converted into electrical currents which flow through the coils of wire on the armature.

The current in the armature flows alternately in different directions through the wire wound thereon. It is generally caused to flow con-

stantly in one and the same direction by means of a contrivance called the commutator.

The current so produced flows out of the machine, through a conducting wire, into and through a number of lamps placed at suitable points in the length of the wire, and finally through a continuation of the wire back to the machine.

The path of the current from the machine to the lamp, and out of the lamp back again to the machine, is known technically as an "electric circuit."

Any conductor is said to be placed in an electric circuit, or to form part of an electric circuit, when it is so arranged that the current from the machine or battery causing the electricity can flow through it and back again to the place where the current was produced. That is, anything placed in an electric circuit forms part of the conducting path through which the current is circulating.

Dynamo-electric machines are now made to furnish very powerful currents; currents capable of sustaining fifty or more arc lights in one circuit or line. Such currents require care in their management, and judgment in their introduction into buildings or public places for purposes of illumination.

Fortunately, however, the currents produced by dynamo-electric machines have some properties very different from those produced by the ordinary frictional machine. The former possess little or no power of leaping from one conductor to another across an intervening non-conductor, such for example as air; the latter can, as is well known, readily so pass, often through several feet or more of dry air.

The currents from dynamo-electric machines, or the currents employed in systems of electric lighting, are not, therefore, at all comparable to strokes of lightning, to which they have often been ignorantly likened. Lightning discharges frequently pass through miles of air, but, even in the largest machines, the carbons employed in arc lamps must first be brought into contact and afterwards separated, before the arc is established and the current passes between them. The current will not, in fact, leap through the air. The momentary contact of the two carbons develops sufficient heat to form a cloud of carbon vapor between them, and this cloud, being an electrical conductor, permits the current to pass.

When, however, the cloud of vapor is once established between the two carbons, it will continue to pass until the carbons are sufficiently

~~and so for any other proportion. In other words, the currents will be~~ consumed to cause the distance between them to become too great to be bridged over by the vapor. While, therefore, the current possesses little or no power of so leaping through air, yet it is necessary that no opportunity be afforded it to form such conducting clouds between it and neighboring conductors. A brief mention of some of the ways in which such clouds may be formed will, therefore, be of practical importance.

If two bare metallic wires, conveying powerful electrical currents from different sources, be brought into contact and then gently separated, a cloud of metallic vapor may be formed between them, as in the case of the carbon electrodes.

Or if any portion of a bare wire be brought into contact with one part of a metallic conductor, and a distant part of the same wire again touches this conductor, an arc of flame may be established between the wire and the conductor.

To speak more generally, if any conducting material be placed in, or form a part of the electrical circuit, and from any cause a momentary break be made between it and the rest of the circuit, an arc of flame may result.

As these arcs of flame are very hot, their occurrence should be carefully prevented in all places except between the carbon electrodes in the lamp.

Dangers of this character may be entirely avoided by carefully insulating all the wires which carry the electrical current into or out of the building or space to be lighted.

The comparatively feeble leaping power of the currents developed by dynamo-electric machines, as already referred to, does not, however, necessitate any very high degree of insulation for the wires. Whatever the character of the insulation employed, care should be exercised to insure its being preserved intact on all parts of the wire. The removal of the insulation from but a few points of the wire might cause a dangerous discharge at such points.

When two different paths are open to the current, it will flow through both such paths. If these paths are of different conducting powers, more current will flow through the path which is the better conductor. If one of the paths be twice as good a conductor as the other, twice as much current will flow through it. If it be a hundred times a better conductor, a hundred times more current will flow through it; and so for any other proportion. In other words, the currents will be

divided between the different paths in proportion to their conducting powers.

Suppose, now, that two different portions of an electrical circuit be bridged over by any conducting material. Say, for example, that a wire from a line of telegraph or telephone falls across a line of electrical conducting wires, so as to connect the wire carrying the current from the machine with a part of the wire carrying the current back to the machine. If such electrical conducting wire be uninsulated, a series of cross contacts would thus be formed, and two different paths be opened to the current. Since the conducting power of the short wire, forming the cross circuit, would probably be far greater than that of the portion of the circuit with its included lamp, the greater part of the current thus "cut out" or "short circuited" would pass through the cross wire, either fusing it, or drawing dangerous arcs of flame when the contacts were at times but partial.

This danger may be entirely obviated by insulating the wire. It is therefore preferable to insulate all parts of the wires that lead either from, or to the machines producing the current.

If the human body be accidentally placed in the circuit, the partial or entire passage of the current through it may, if the machine be powerful, cause instant death, or, if the machine be of smaller size, produce a painful shock.

But to enable the current so to pass, the body must be placed in the circuit of the machine, that is, the current must be able to enter the body at one point, and to pass out and back to the circuit from another point, or, in other words, a break must be made in the wire, and the body inserted in this break.

Here again the difference between the current from dynamo-electric machines and from the common frictional machine, is to be carefully noted. Merely touching any part of a charged conductor of a frictional electrical machine, will completely discharge it, the person conducting the discharge through his body to the ground. A person touching any part of a bare conducting wire, while it is conveying a powerful electrical current, such as used in systems of lighting, would not convey the discharge through his body to the ground, because he would not be placed in the circuit. He has simply provided a place for the current to enter, but none for it to flow through him and back to the machine whence it originated.

Should, however, one portion of the wire touch the ground in any

place, especially where it is wet, then his feet might be connected through the damp ground with another part of the circuit, and two paths thus be opened to the current, with the chances of a dangerous portion thereof passing through his body.

To guard against dangers of this character it is necessary to thoroughly insulate the wire in all places where it is liable to be touched. It is far preferable to establish a continuous metallic line of conductors both to and from the machine, rather than ground the wires, and so necessitate the current to pass through the earth in order to flow back to the machine.

During the burning of lamps of the arc type fragments of highly heated carbon sometimes become splintered from the electrodes and fall below. To avoid danger from this source a cup should be placed below the electrodes to receive any fragments that may fall.

It would follow, from the principles thus briefly enunciated, that there may arise two kinds of dangers from the employment of powerful electrical currents for the purposes of artificial illumination, viz.: Dangers to property from fire; and dangers to life. With the exception of that due to falling fragments all these dangers may be readily and completely avoided by properly and thoroughly insulating the wires that carry the current to and from the machine, while that due to falling fragments may be easily avoided by the means above pointed out.

In order, however, to particularize these different kinds of dangers, and to point out more especially the proper remedy for the avoidance thereof, the committee recommend that the following precautions be taken in all cases where electric lighting is employed, viz.:

1st. That the conducting wires leading into and out of the building be suitably insulated throughout their entire extent, both to and from the machine producing the current.

2d. That an inspection be made at suitable intervals to determine whether or not the insulation has been preserved intact.

The insulation may become impaired by the following causes, viz.:

By the wires being cut by the staples or hooks used in securing the conducting wires in position.

By the wires being placed in positions subject to abrasion, either by chafing with another wire, or from any other cause.

By the wires turning sharp bends, or by being sharply bent by any cause whatever.

3d. That conductors formed of numerous short pieces of wire be avoided as far as possible, and that where their use is necessary the joined ends be made as secure as possible by wrapping, so as to prevent short arcs being formed at imperfect junctions, should the joined ends be partially separated from each other.

4th. That the wires be not grounded, that is, that no attempt be made to cause the current to pass back to the machine through the earth, but that a continuous line of wire be provided, through which the current shall so return.

In order that this precaution may be effective, the wires should not be carried near metallic bodies like lines of shafting, nor gas nor water pipes, because an accidental contact of the conductor with any of these would effectually ground that part of the wire. Where it is necessary that the wire cross such metallic bodies, it is advisable that the insulation be made better than usual at such junctions.

5th. That the ready occurrence of cross contacts or short circuits be avoided, as follows, viz.:

That the conducting wires from different machines, or from different parts of the same machine, be kept as far apart as convenient, and never, except when necessary, be brought nearer together than the distance between the two binding posts on any electric lamp used in the circuit.

That therefore the wire leading from the machine into the room to be lighted should leave the room as far as convenient from the place it enters.

That the wires be securely fixed in position and be not allowed to sag or bend in wide curves, except where it is necessary to permit the raising or lowering of the lamp.

That judgment be exercised in selecting the portions of the building in which to run the wires. To secure as far as possible the absence of moisture, ceilings are to be preferred to walls or floors, the latter being highly objectionable, unless the wires are placed under the flooring. As before stated, the location selected should be removed as far as possible from metallic conductors. Select the places least liable to be rendered partially conducting by moisture from any source, in which to run the wires.

6th. That the conducting wires be of sufficient size to carry the most powerful current employed without dangerous heating.

7th. To avoid the danger to life from the accidental discharge

of the current through the body, the conducting wires should in all cases convenient be placed out of reach, either by choice of location or the use of heavy and guarded insulation.

8th. That where lamps of the arc type are used, they be covered with a globe of glass, and that the lower end of such globes be furnished with a cup or pan for retaining any heated fragments.

The committee believe that if these precautions be taken electric lighting can be thoroughly safe and reliable, and that all dangers attending its use can be entirely obviated.

R. E. Rogers, M.D., *Chairman.*
Charles M. Cresson, M.D.
David Brooks.
E. Alex. Scott.
Edwin J. Houston.
Isaac Norris, M.D., *Secretary.*

REPORT of COMMITTEE of the FRANKLIN INSTITUTE on FIRE-ESCAPES and ELEVATORS.

Your committee appointed "to examine and report upon the principles which should govern the erection of fire-escapes and lifts or elevators in new buildings and on those now erected," respectfully report that they have held four meetings, have examined a large number of models, designs and plans submitted to them by inventors, have individually examined means of escape now provided in many mills, hotels, etc., and after a full discussion of the subject have reached the conclusion, that while it is impossible to specify any particular form of escape applicable to all buildings, they can nevertheless lay down some general principles that should govern the erection of stairways and other fire-escapes.

As a general rule, applicable to all buildings, the main reliance should be placed upon stairways in daily use, for the obvious reason that the occupants of a building instinctively seek such an escape in case of fire, that they are familiar with it, and that, being in daily use, it is reasonably certain to be unobstructed and to have the approaches to it clear. For these reasons, and because a stairway is usually broader and easier to descend than any special contrivance such as a

ladder, probably ten times as many persons can escape by a stairway, in a given time, than can descend by any form of ladder or stairway used exclusively as a fire-escape.

Stairways, however, as ordinarily constructed, are liable to be cut off by smoke, or by fire itself. The best plan to make them safe in this particular is to have two or more stairways accessible from every room, separated therefrom by a broad air space but connected by bridges at each story. These stairways and bridges should be incombustible and the stairways enclosed in brick walls. This plan may easily be adopted in a group of mills and even where the stairways in existing mills do not answer all the desired conditions, the building of bridges connecting isolated buildings will add to the safety of the operatives. Where there is a single building with sufficient yard space to permit the construction of stairways in isolated brick towers, approached by bridges from each floor of the mill, the same *system* of fire-escapes can be applied.

In single buildings in the closely built parts of the city, where the bridge system cannot be applied, the first and most reliable means of escape is an internal stairway or, preferably, two stairways, one at each end of the building. They should be entirely enclosed in brick walls (fire walls) and be built of incombustible materials. Their safety will be increased if they start from the ground floor and are entirely shut off by stone or brickwork from the cellar. The danger of smoke entering them in such volume as to make them useless will be lessened if the necessary doorways by which communication is had with the rooms on each floor be made low and closed by iron-encased wooden doors, closing automatically, but always free to be opened by pressure from within. Circular stairways should be avoided, and straight stairways, with turns at each floor, should also have half landings to make rapid descent less dangerous.

In a building occupying the whole of the available lot, but which is large enough to admit of the construction of two stairways, one at each end, almost absolute safety with internal stairways can be secured by the following plan: Build both stairways of incombustible materials, substantially as heretofore described, but have no openings whatever to one of them from the interior of the structure. The stairway leading into the rooms would be used for the ordinary purposes of business, both for ingress and egress. The other stairway should have openings to *external* balconies on each floor, extending

over one, two or more windows of the main building. In the event of fire, both stairways could be used, if smoke did not obstruct the one opening into the mill; but if that were cut off from any cause, all the occupants, by passing out on the balconies, could enter the other brick-enclosed stairway which, having no direct connection with the building, would not be liable to be cut off by either flames or smoke.

For the class of buildings which, by reason of their small size, can have only one internal stairway, some form of external escape is needed, for it should be laid down as a rule that one stairway or one means of escape, however good in itself, cannot, in the nature of things, insure safety. It must always be liable to be cut off by fire or smoke. Every additional means of escape gives an increase of safety; but two, if widely separated, and of themselves good, may reasonably be deemed sufficient in buildings not large enough to permit the erection of more.

Of the many devices for external means of escape none that have been submitted to your committee can be recommended for all purposes, though several have merit and may be absolutely necessary in some buildings. Your committee believe that an external means of escape should be of the nature of a stairway, not of a chute, nor an elevator of any kind, nor a car to be lowered and hoisted to high windows, nor any other kind of apparatus dependent upon moving parts which are liable to be out of order when wanted, especially when used only on rare occasions. The objection to the chute form of apparatus is that it is an unusual means of egress in which terrified people could place no confidence.

The stairway forms of escape include ladders of all kinds, but the straight ladder exposed to the weather is the most objectionable form, because women and children can make little use of it, and in winter time it might be dangerous and practically useless even to experienced climbers.

A modified form of the straight ladder, which is set away from the wall so that the latter gives support to those who are descending and which also has side guards to prevent one from falling, is an improvement on the ordinary straight ladder set against the wall. The stairway-ladder, running obliquely down a building and furnished with a hand-rail, is also superior to the straight ladder, but, to make it at all safe, some light will have to be sacrificed in most mill buildings, for it should not cross open windows and thus be liable

to be cut off by flames or smoke from a lower story. It seems desirable that, in any form of ladder or stairway exposed to the weather and built of iron, the treads should be flat, covered with a light strip of wood and perforated.

One other form of external ladder escape submitted to us had the ladder itself, together with its balconies, suspended from a rail under the cornice, so as to permit it to traverse the building and be fixed opposite any set of windows which might happen to offer the best chance of escape. While this device is open to the general objection of being movable, and therefore liable to be out of order when wanted, this objection is not of much weight since, in its normal position without being moved, it is ready for service and may be regarded as a fixture. It is as good as a fixed ladder of similar form if not moved, and it *might* be better than a fixed ladder if its position could be shifted.

Your committee does not feel called upon to decide as to the relative merits of these ladders to be used as external means of escape, further than to point out what are regarded as their general merits and defects, for the reason that they regard the manner of constructing internal stairways in daily use as of paramount importance, and look upon all extraordinary means of escape as of comparatively little value. They, nevertheless, recognize the fact that external means of escape may be absolutely necessary for some buildings, and therefore set down as principles to govern their erection that they should be of stairway form (including in this category ladders), that they should be carried up to the roof of the building to permit escape in that direction, that they should be erected on the piers of buildings and in no case cross open windows, or windows not permanently closed by shutters, and that the treads of the ladders should be flat and covered with some material, such as wood, not as likely as iron to be covered with ice or made slippery by snow in winter time.

It has been suggested that adjoining buildings in the closely built parts of the city might be provided with external means of escape by the erection of balconies connecting the windows of different buildings on each floor. If a fire occurred in one building, its occupants could go by the balconies into the other and escape by its stairway, shut off from the fire by the dividing wall. It would be necessary, of course, for the owners and occupants of such adjoining structures to consent to having this connection made, which circumstance would limit its applicability. The chief objection to it, the

danger of robbery being committed by way of the balconies, is not so serious as might at first appear, because the two buildings are generally occupied during the same hours, the balconies are exposed to view, and at night, when one or both buildings have been vacated, the windows leading to the balconies could be secured against the entrance of thieves except by noisy violence.

Your committee is aware of the existence in the city of a large number of manufacturing establishments, on the upper floors of what were formerly dwelling houses, which are exceedingly dangerous to human life. They are filled with inflammable material, are not carefully looked after, and the stairways leading to the upper floors are either unenclosed, each stairway terminating at and opening directly into the room to which it leads, or the stairways and entries are, to save space, divided from the rooms by an inch board partition. In such buildings there is special danger of fire, and if it occurs on the lower floors the stairway may in a few minutes be cut off by flames or smoke. A reasonable degree of safety can only be secured in such buildings by requiring the erection of a brick enclosed stairway, and most of them should also be provided with external means of escape.

Where such a building has no back outlet, and is so narrow that the stairway cannot be erected in the front without destroying the value of the property, a brick enclosed stairway erected in the centre of the length of the building, against the side wall and leading from the upper floors to a passage way in the cellar, but completely separated therefrom by a brick wall, would offer a means of escape to the street without sacrificing the more valuable parts of the building. Whatever the expense and inconvenience may be, however, these manufactories constructed from dwelling houses should be made safe. They are at present more dangerous than large mills and public halls erected for the purposes for which they are used, although these are occupied by a larger number of persons.

One objection to the use of external, or extraordinary means of escape of any kind, that they are liable to become obstructed, and that occupants of the building may not be aware of their existence or the manner of reaching them, can be obviated by closing up the ordinary stairway one afternoon of each week and requiring the operatives to leave the building by means of the escape. This could be done systematically on a certain day of the week without special inconvenience to the

occupants of the building, even in stormy weather, *if the escape were of practical value*, and if it were not, the sooner that fact became known the better.

The resolution under which we were appointed refers to us the question of lifts or elevators as well as fire escapes. They undoubtedly add to the risk of a spread of flames and smoke through a building, but they are absolutely necessary in large hotels and manufactories. To make them as little dangerous as possible they should be enclosed in incombustible walls, should be free from wood work about the openings in the floors, and, preferably, should be automatically closed by iron encased wooden doors when not in use.

In preparing the general report as above submitted no special attention was given to the law of the State and its requirements, the purpose being to indicate the principles which should govern the erection of fire escapes, supposing the owners of property to be untrammeled by law. It must not be forgotten, however, that the law of the State requires the erection on certain buildings (generally speaking, all buildings three or more stories in height, except private dwellings) of "a *permanent, safe, external* means of escape therefrom in case of fire."

Your committee regards these qualifying words as unwisely specific. The means of escape should be such as to satisfy an official or Board of officials charged with the duty of seeing that such escapes are erected. The chief objection is to the word *external*, for in the majority of cases internal stairways, properly constructed, afford the best means of escape, and, by some forms of construction, make external means entirely unnecessary. The word "permanent" (in the sense of fixed) may rule out otherwise useful means of escape. The word "safe" may have any meaning, according to the judgment of the individual passing upon the merits of a fire escape.

Your committee would recommend, therefore, that at the earliest possible moment the law should be amended in this particular. In the meantime property owners, however well provided they may be with escapes, will have to run the risk of the penalties imposed by the act if they fail to comply with its terms.

Several ordinances having been offered in Councils to provide for an enforcement of the law, your committee deem it their duty to suggest that provision should be made for vesting authority to pass upon fire escapes in a single department of the city government, and that it should be required to approve the plans for fire

escapes *before* they are erected, and to prescribe a form where the property owner fails to submit one. This Board should also be given large discretionary power as to the kind of escape required on different buildings, and should be required in all cases to consider the character of the building, the nature of the business carried on therein, and the number of persons liable to be exposed to the dangers of fire. A plan of escape having been approved by the proper authorities, and the escapes erected in accordance with the plans, the owner of the building should be given a certificate, to be accepted as a sufficient defence in suits for damages, provided the building and fire escapes had been maintained as designed at the time the certificate was granted. Owners of properties making alterations should be required to take out new certificates. The officers charged with the duty of examining fire escapes and granting certificates should be paid by salaries; and the fees collected from property owners, if any, should be no more than sufficient to pay the reasonable expenses, and should be paid into the City Treasury.

It is also desirable that the work of examination should either be given exclusively into the hands of the Inspectors already charged with the duty of approving plans for new buildings and alterations, or be given to those Inspectors, subject to approval, in the matter of fire escapes, by the Fire Marshal. In either case, the way to get plans examined and certificates granted should be made as simple and free from delay as possible.

In submitting this report your committee desire to add that our aim has been only to lay down such *general* principles as seemed to us wise and proper, both in regard to fire escapes and to the character of the legislation which should govern their erection. The details of the escapes can only be properly considered by reference to particular buildings, and the details of the law should be left to the consideration of our law makers.

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CHEMICAL METHODS FOR ANALYZING RAIL-STEEL.

By MAGNUS TROILIUS, Chemist to C. P. Sandberg, London, Eng.

Read before the American Institute of Mining Engineers, October, 1881.

Continued from page 338.

By comparing these formulas with those of the bromine and ammonia process, I think a pretty clear view may be had of the different conditions of the two methods, without further comment.

After what has just been shown, there is no disguising the fact that the bromine and ammonia process is more rapid and convenient than the process with fixed alkaline salts; but it should be here pointed out that a great mistake is often committed in saying that it is impossible to free the precipitate from alkali by washing. Professor Eggertz has stated that by means of cold water containing one per cent. of hydrochloric acid the precipitate may be easily freed from alkali. In Germany, where the fixed alkali method is used, this mode of washing is not so frequently known as might be supposed, and at one works I was told that experience went to show that by using chlorine instead of bromine the washing of the precipitate with ordinary hot water could be more easily effected.

When chlorine is used for precipitating the manganese, no ammoniacal salts must be present, otherwise the explosive compound Cl_3N may be formed. On the other hand, in the case of bromine and ammonia, no explosion need be feared.

The different methods, of which the outlines have now been given, yield quite concordant results when carried out by experienced hands, and for rail-steel there is certainly no preference to be given to any of them so far as accuracy goes. According to my own working, the results should not vary more than 0·05 per cent. and the time required for an estimation one day; of course several assays can be made at the same time. As to rapidity, the bromine and ammonia process will no doubt prove the best, for reasons stated above.

There are many volumetric methods for determining manganese, but, as far as I have seen, none is more rapid than the gravimetric method with bromine and ammonia. A new volumetric method has been recently devised in the Stockholm School of Mines and will shortly be published.

Sulphur Determination.

I dissolve 5 grammes of steel in aqua regia and separate the silica in the usual way. In the boiling solution, the sulphur is precipitated by means of 2 cc. of a concentrated solution of chloride of barium. Boiling is continued for a short time and the solution is then left to stand during one night.

The sulphate of baryta, before being taken upon the filter, is decanted repeatedly with hot water. Some drops of hydrochloric acid must be added to prevent oxide of iron from being precipitated. By washing carefully in this way accurate results are secured, always provided that the reagents are pure. The purity of the reagents is, indeed, the difficulty in this method, as it is almost exceptional to find the acids bought as "special" free from sulphur. The sulphur must be estimated in the reagents and the necessary deductions made.

There are chemists, however, particularly in Germany, who assert that even with pure reagents you will get too high results by the aqua-regia method. They therefore use the bromine method, leading the gases from the steel dissolving in dilute hydrochloric acid through a solution of bromine in hydrochloric acid. The sulphuretted hydrogen is thus oxidized and can be precipitated in the usual way, by means of chloride of barium.

As far, however, as I have been able to see, the bromine method gives too low results. I have had to determine the sulphur in steel with the aqua-regia method against chemists using the bromine method, and on some occasions I have found 0·08 per cent., while the others have found only half of this, 0·04 per cent. By means of the Eggertz silver plate, however, I easily ascertained that 0·04 per cent. was much too low. The experiment was carried out by hanging a clean, small silver plate over the gases evolved from 0·1 gramme of steel, dissolving in 1·3 cc. of sulphuric acid of 1·23 sp. gr. The plate then got a decidedly more bluish than brownish color, whereas if the percentage of sulphur had been only 0·04 per cent., the color would have been simply brown and not blue at all. This plate method was worked out by Professor Eggertz, and has been for many years in use at all blast furnaces in Sweden for the daily testing of every cast of pig iron. The plate method will yield very good results for percentages of sulphur between 0 and 0·4 per cent., and this is quite sufficient for Swedish irons. But for sulphur over 0·04 per cent., the method is less accurate, except in extremely well-trained hands,

and one can only make a rough estimation, as a rule. The relations of the colors of the plate to the percentage of sulphur is shown by the following table:

No color,	0·00 per cent.
Slightly yellowish,	0·01 "
Yellow,	0·02 "
Yellow-brown,	0·03 "
Brown,	0·04 "
Blue,	0·20 "

Between brown and blue there are numerous variations in color. A certain red tint signifies 0·10 per cent., but this can only be learnt by practice.

APPENDIX.

COLOR TEST FOR CARBON IN IRON AND STEEL.—By V. EGGERTZ.

(Translated from the Swedish by M. Troilius.)

The first description of this method appeared in the *Jernkontorets Annaler*, of 1862, page 54, and in the *Berg- und Hüttenmännische Zeitung*, 1863, page 373. Subsequently, several additions were made to this description in the *Jernkontorets Annaler*, 1874, page 176, and in the *Berg- und Hüttenmännische Zeitung*, 1875, page 440. At that time I considered that it would be practically sufficient to determine the carbon in tenths of a per cent., but I now find that even hundredths of a per cent. are required.

For commercial purposes, however, iron and steel is generally stamped with only whole or half tenths of a per cent. of carbon, it being chiefly for the softer irons and steels with carbon between 0·10 and 0·25 per cent., that the greater accuracy in determing the carbon is required.

Pure hydrate of oxide of iron, containing 0·1 gramme of iron and free from chlorine, will give a yellow-greenish solution when dissolved in 2·5 cc. of nitric acid, specific gravity 1·2. The solution will lighten somewhat on addition of 1·5 cc. of nitric acid, but not so much as when water is added instead of nitric acid. When hot, the solution has a much darker color than when cold. By adding 4 cc. of water in either of these cases, so as to make the bulk up to 8 cc., the iron color will be totally got rid of. Hence the rule for color tests for

carbon, that the solution of iron must be diluted with a volume of water at least equal to the volume of nitric acid used for dissolving the iron, and that the volume of the solution must not be smaller than 8 cc.* when the color is to be observed.

The nitric acid as well as the water must be entirely free from chlorine or hydrochloric acid, which otherwise will give a yellowish color† to the solution, even if present in only very small quantities. The quantity of nitric acid should correspond to a certain extent to the amount of carbon supposed to be present in the iron. For iron containing carbon 0·25 per cent., 2·5 cc. are thus used for each 0·1 gramme, for 0·3 per cent. 3 cc., for 0·5 per cent. 3·5 cc., and, finally, for 0·8 per cent. 4 cc. For steels with more carbon 5 cc. should be used. The last-named quantity is also to be used for white pig irons, of which, however, 0·05 gramme only are carefully weighed out for each test.

When the amount of carbon is quite unknown 2·5 cc. of nitric acid are added to start with, and then more until it is indicated by either the color or by the quantity of separated carbon-substance that no more acid is wanted. A little more acid than the quantity just mentioned does no harm, if only an equal volume of water is afterwards added. Thus for white pig iron 7 cc. may well be taken so as to prevent a too quick precipitation of organic matters after diluting. With too little acid a too dark solution will be obtained. Thus, if 0·1 gramme of steel containing 0·8 per cent. of carbon is dissolved in 2·5 cc. of nitric acid only, instead of 4 cc., the color of the solution will, after dilution, represent a percentage of carbon equal to about 0·9 per cent.

The iron for testing is to be finely divided either by filing,‡ by aid of a good clean file, or by means of a boring machine (which is preferable), by rubbing with some hard steel edges, or by crushing in a steel mortar, if it is very hard.

The test-tubes for dissolving the steel should have an internal diameter of 15 mm. and a length of 120 mm. The tubes are to be cleaned

* For each 0·1 gramme of iron.—M. T.

† Only 0·0001 gramme of chlorine produces a distinct yellow color in a solution of 0·1 gramme of iron (from hydrated oxide of iron) in 2·5 cc. of nitric acid. This color can be noticed even on addition of 1·5 cc. of nitric acid and 4 cc. of water. Upon further diluting, the coloration becomes less distinguishable.

‡ Worn-off particles from the file may, however, greatly increase the percentage of carbon in the iron.

out by means of coarse filter-paper rolled together and well cut at the edges. 0·1 gramme of the iron or steel for testing, or in the case of white pig, 0·05 gramme, carefully weighed, is then put into the tube and 2·5 cc. or more of nitric acid of specific gravity 1·2 added. The acid may be readily measured off in a little measuring glass of 10 mm. diameter and 75 mm. length, and graduated so as to show whole or half cubic centimetres. The tubes are covered with small watch-glasses (23 mm.) and put into a cylindrical vessel of copper-plate having a height of 100 mm. and a diameter at least of 120 mm. This vessel is covered with a copper plate provided with a thermometer and holes for the tubes. The holes are marked with engraved figures. The vessel is to contain water and a few grammes of paraffin to prevent the evaporation of the former, and is heated to 80°C. by means of a gas flame. This temperature should be kept up all the time. The tubes are shaken now and then, and the solution is completed when no further gas bubbles appear. One and a half to two hours, or sometimes longer, time is required to effect complete solution, the time depending upon the amount of carbon in the iron.

Up to the present time this has been the ordinary way of proceeding, but it is shown by experience that the keeping up of the temperature of 80°C. requires more care than has been generally taken. Of course, this has been of less influence as long as fresh weighings of the standard steel have been dissolved along with every set of samples for testing. But if it is desired to avoid the frequent dissolving of standard steel and to use permanent standard solutions (see further down) then the iron must always be dissolved at the same temperature. For this purpose it is the safest way to put the tubes into boiling water. By this means the time for dissolving may be shortened to about three-quarters of an hour, and the color of the fluid will then turn out a little darker than by dissolving at 80°C. If, occasionally, greater rapidity is required the solution may be effected by boiling over a lamp flame; between the flame and the tubes there should be put a brass gauze with the tubes resting on it. The color will in this case generally be somewhat darker than when dissolved at 100°C. The reason for heating to 80°C. instead of 100°C. has been, that in the latter case there is sometimes a reddish-yellowish deposit formed on the glass; when brought down into the fluid this matter has made the solution turbid. The deposit must

be dissolved by shaking if possible, otherwise it must be filtered off. It consists of nitric acid and oxide of iron. This is borne out by the fact that it also arises by heating a solution of pure hydrate of oxide of iron in nitric acid.

All gas bubbling having ceased, the tubes are taken out of the hot water and put into a beaker containing cold water. They should be covered in some way so as to be totally excluded from the daylight, which would soon give too light a color to the solutions. If protected in this way the solutions will retain their color for many days. The burette for determining the carbon should have 30 cc. capacity and be graduated into tenths of cubic centimetres and be provided with one large and one small mouthpiece at the upper end. The solution is brought into this burette through a filter, if necessary, as for instance if the fluid is turbid or graphite is present. Then distilled water is to be added; the quantity of water, including the water used for cleansing the test-tube, must be at least equal to the quantity of nitric acid used, and the total volume must not be less than 8 cc. when it is to be compared with the standard solution. The standard solution is prepared by dissolving standard steel. It should be diluted with water so as to make each cubic centimetre of the same to correspond to 0·1 per cent. of carbon. It may also be carefully diluted with more water so as to have each cubic centimetre =0·05, 0·02, 0·01 or 0·005 per cent. of carbon, of 0·1 gramme of iron or steel used. For example, dissolve 0·1 gramme of standard steel, containing 0·8 per cent. of carbon, in 4 cc. of nitric acid and add water to 8 cc. The solution is to be carefully mixed after each addition of water; otherwise the lower part of the fluid will appear too dark. After mixing, at least one minute should be allowed for the fluid to run down along the sides of the burette before reading off, which is done at the upper border of the fluid.

The above-mentioned standard solutions, representing the total, half, fifth, tenth and twentieth of the standard, may be marked and used as follows:

	Percentage of carbon per cc. for 0·1 gramme of iron.	To be used for iron with a percentage of carbon =
N	0·10	0·8 and more
$\frac{1}{2}$N	0·05	0·4 —0·80
$\frac{1}{5}$N	0·02	0·16—0·50
$\frac{1}{10}$N	0·01	0·08—0·25
$\frac{1}{20}$N	0·005	0·04—0·08

The smallest percentage of carbon* found in iron in this country is 0·04 per cent. A good daylight is required when using the last-named standard solution, and this remark applies to all colorimetric tests.

The dilution cannot be carried farther than twenty times the original solution in the case of using the ordinary burettes of about 12 mm. diameter. But one can sharply distinguish the difference in color between ordinary distilled water and a standard solution diluted to forty times its original volume and, therefore, if one uses burettes of 24 mm. diameter, it will be possible to approximately determine the carbon in iron containing only 0·02 per cent., supposing such soft iron to be produced. In this case measure off 1 cc. of the "N" solution in a delicate measuring tube and dilute to 40 cc. Thus 1 cc. will be equal to 0·0025 per cent. of carbon. Pour this standard solution into the 24 mm. tube. This tube should exactly correspond with another graduated 24 mm. tube, in which 0·4 gramme of the iron for testing is to be dissolved in 10 cc. of nitric acid, the solution diluted to 32 cc. and then more until the colors agree. For instance, if the colors agree at 35 cc. bulk, you find the percentage of carbon thus:

$$0{\cdot}0025 \times 35 \div 4 = 0{\cdot}022 \text{ per cent.}$$

Hitherto it has been the usual practice to compare colors by holding a piece of thin filter-paper behind the tubes. In this way, however, one is much dependent on the distribution of light in the room, which, therefore, ought to have only one window for this purpose. For most people's eyes the left-hand tube will appear somewhat darker than does the right-hand tube. For this reason it was originally prescribed that the tube containing the solution of iron or steel for testing should be kept to the right so as always to have it in the ssme position. In order to avoid being dependent on the room I work in, and to lessen the difference in color between the left- and right-hand tubes, I now most advantageously use a contrivance in the shape of a little camera, into which the tubes are put. The camera is made of wood 6 mm. thick, and is open at both ends. The inner sides are blackened. The internal height is 80 mm., width of forepart 26 mm. and width behind 120 mm. The tubes are put in the forepart through apertures in the upper part of the camera and steadied at the bottom by a gutter of copper plate and at the upper part by a brass wire. The

* By means of the iodine method 0·038 per cent. of carbon was once found in 8 grammes of a Swedish Lancashire iron.

box is closed at the wider end by means of thin filter-paper* nailed to it. Burettes and tubes should be closely of the same quality as to color, etc., and be wiped with clean linen before being put into the camera.

We have of late been using as standard steels two Bessemer steels, one of which contains ·80 per cent. and the other one ·16 per cent. of carbon. These steels are kept in pieces 12 mm. square. Samples from these pieces are always taken at right angles to the longitudinal axis. The carbon in these steels was determined by me by aid of the iodine method, as described in the *Jernkontorets Annaler*, 1862, page 47. 5 grammes were taken for each test. Three analyses of the harder steel showed ·79, ·80 and ·82 per cent. of carbon, and two analyses of the steel containing ·16 per cent. agreed very closely. These carbon determinations also agree very well with those of Dr. A. Tamm, whose results by combustion are described in the *Jernkontorets Annaler*, 1874. The iodine method is now modified, so that instead of using iodine direct for dissolving the iron or steel, a solution of iodine in iodide of iron is used. This is on account of the difficulty of obtaining pure iodine. The solution now used is prepared by dissolving 10 grammes of iron in 50 grammes of iodine and adding another 50 grammes of iodine, which is readily dissolved. The solution is filtered and water passed through the filter until a bulk of 100 cc. is reached. 10 cc. of this solution are required for 1 gramme of iron. With regard to the diminution in weight of filter-paper on being treated with acid, we have generally used platinum filters for collecting the carbonaceous matter. However it is somewhat difficult to obtain good platinum filters and, therefore, it seems preferable to use filter-paper which has been treated with hydrochloric and hydrofluoric acids,† whereby the inorganic ingredients are almost completely extracted. A filter of 60 mm. diameter thus treated does not give more than 0·0001 gramme ash. The carbonaceous mass should be dried on a water-bath at a temperature of 95°—98°C. For this purpose the mass is put into a crucible, and the crucible then put into a glass tube, closed at one end and having a length of 130 mm. and diameter of 35 mm. The upper end of the tube is closed by means

* This can also be effected by applying a screen holding a glass adapted to the eye as to convexity or concavity, and having about 40 mm. diameter.

† Fresenius' Zeitschrift, 1879, p. 582.

of a cork, through which hangs a thermometer. The crucible may be inserted or removed by means of a crooked brass wire.

Even for white pig iron better results than could be expected* are now obtained by the color test. The difficulty in this case lies in the use of only 0·05 gramme, and still diluting to a very large volume, which renders a slight error in observation very important. The solutions of white pig iron should be rapidly read off, for the reason that they soon become turbid with a precipitate of organic matter. This inconvenience may, to a great extent, be removed by using 7 cc. instead of 5 cc. of nitric acid.

The mode in which the carbon is present in the steel as "cement carbon," or "hardening carbon," does not influence the color test otherwise than to render the solution less dark in the latter case, when the carbon is more intimately combined with the iron. Thus a steel containing 0·8 per cent. of carbon showed only 0·55 per cent. after strong hardening and crushing. After reheating the steel to a low red heat, the original percentage of carbon was again obtained. By aid of the iodine method, 0·8 per cent. of carbon was found in 5 grammes of the hardened steel. A piece of iron containing 0·3 per cent. of carbon, upon being hammered down cold from 12 to 6 mm. square, showed the same carbon before and after hammering.

Different kinds of iron and steel behave very differently during dissolving, some solutions at once becoming colored, others only after heating. The final color, however, after diluting with water, generally tallies very well with the color of the standard. In case there should be any difference in tint—yellow or brown—it is best to notice the intensity of colors, which can be done by holding a thin filter-paper behind the tubes and observing through which tube one can most easily see certain dark points in the paper, etc. It is a matter of course that some persons are able to use the color test with greater advantage than others, according to their different eyesights; but eyesight may be considerably improved in this respect by practice, as shown by experience; in fact, only very few have hitherto been found incapable for this work.

The following experiments have been made with regard to the influence on color exercised by foreign substances in iron and steel:

Manganese.—0·05 gramme, contained in carbonate of manganese,

*Jernkontorets Annaler, 1874, and Berg- und Hüttenmännische Zeitung, 1875, p. 440.

was dissolved in 2·5 and 5 cc. of nitric acid. The color thus obtained was brown, owing to the presence of a little oxide of manganese. After heating to 100°C. a small precipitate was obtained (in all probability hydrated dioxide), and the solution assumed a slightly reddish color, which disappeared after diluting with water to 8 or 10 cc. These experiments show that the color test may be used for determining the carbon in ferromanganese. A ferromanganese containing 80 per cent. of manganese showed 4 per cent. of carbon by color test.

Phosphorus.—0·001 gramme, contained in phosphate of sodium, was added to a solution of 0·1 gramme of iron (as hydrated oxide) in 2·5 cc. of nitric acid and 2·5 cc. of water; no difference in color was noticed after this addition. Iron containing 5 per cent. of phosphorus is difficult to dissolve, and with 10 per cent. of phosphorus it is insoluble in nitric acid.

Sulphur.—0·001 gramme, contained in sulphate of magnesia, was added to a solution of iron in 2·5 cc. of nitric acid and 2·5 cc. of water. The color of the solution remained unaltered.

Neither did any alteration in color take place when 0·01 gramme of manganese, 0·01 gramme of phosphorus, and 0·001 gramme of sulphur (all contained in the above-mentioned salts) were added to a solution of 0·1 gramme of iron (as hydrated oxide) in 5 cc. of nitric acid and 5 cc. of water. The same quantities, when added to a solution of 0·1 gramme of standard steel with 0·8 per cent. of carbon, did not alter the color here either.

Copper.—0·001 gramme was dissolved in 2·5 cc. of nitric acid and 2·5 cc. of water. No coloring of the solution.

Silicon in iron and steel is, to a very great extent, dissolved in nitric acid on heating, even if lumps of silica be seen floating about at the beginning of the dissolving process. 0·4 per cent. of silicon in steel has no influence whatever on the color test. Silicious pig irons always contain graphite, which must be filtered off, together with the silica which may possibly have remained insoluble.

Tungsten in iron or steel is converted into tungstic acid (WO_3) when the iron or steel dissolves. It is insoluble, and must be filtered off.

Chromium.—0·002 gramme, contained in hydrated oxide, when dissolved in 2·5 cc. of nitric acid and 2·5 cc. of water, gave a grayish-bluish color to the solution. After addition of water to the double

volume this color grew less distinct. On addition of more water the color gradually grew fainter, and at 40 cc. it disappeared. It is difficult or even impossible to dissolve in nitric acid iron or steel containing much chromium.

Vanadium.—0·001 gramme, contained in vanadic acid (V_2O_5), when dissolved in 2·5 cc. of nitric acid, gives a faint yellow color to the solution. This color disappears after adding 2·5 cc. of water.

Nickel.—0·001 gramme, when dissolved in 2·5 cc. of nitric acid, gives a green color to the solution. This color remains visible after adding 2·5 cc. of water, but disappears at 8 or 10 cc. volume.

Cobalt.—0·001 gramme, when dissolved in 2·5 cc. of nitric acid, gives, as is well known, a red color to the solution. After adding water to 24 cc. this color is hardly visible, but may, however, not be considered removed before diluting to 40 cc.

In my paper of 1862 I pointed out the desirableness of having permanent standard solutions of *inorganic* matters, instead of those prepared by dissolving burnt sugar in spirits of wine, the latter solutions getting lighter after some time, particularly after prolonged exposure to the sunlight. Many propositions have been made of late, in various journals, with regard to this matter, and compounds of iron, cobalt and nickel, as well as potassium bichromate, have been recommended for the purpose. I have experimented upon several such mixtures, and lately, at the suggestion of Professor F. L. Ekman, I have tried the chlorides of iron, cobalt and copper, and I find that these yield the best results, as they allow of the production of any tint in yellow, brown or green. Such mixtures, diluted with water containing 0·5 per cent. of hydrochloric acid of 1·12 specific gravity, have been found to remain unaltered even after a long exposure to the sunlight. The mixture grows more and more yellow by adding hydrochloric acid drop by drop only. I prepare my standard solutions as follows: By adding to the neutral chlorides water containing 1·5 per cent. of hydrochloric acid for the chloride of iron, and 0·5 per cent. for the two other chlorides, I prepare solutions of a strength corresponding to 0·01 gramme of metal per cubic centimetre. Then 8 cc. of the nitric solution are mixed with 6 cc. of the cobalt solution and 3 cc. of the copper solution, and about 5 cc. of water containing 0·5 per cent. hydrochloric acid are added to the mixture. At a temperature of 18°C.* this solution shows exactly the same color as a

* This is an addition made since publishing the paper in the *Jernkontorets Annaler*. —M. T.

solution of steel in dilute nitric acid corresponding to 0·1 per cent. of carbon per cubic centimetre. The solution may afterwards be diluted with water, containing 0·5 per cent. of hydrochloric acid, to any standard color required. The addition of water is almost directly proportional to the percentage of carbon. It need scarcely be mentioned that the quantities, 0·1 gramme for iron and steel, and 0·05 gramme for white pig iron, must be correctly weighed out when artificial standard solutions are used.

Now that permanent standard solutions can be obtained, it seems to be the right time to apply the old method for the determination of copper in ammoniacal solutions. This method was adopted by Mr. J. Blodget Britton, of Philadelphia (*Fresenius' Zeitschrift*, 1871, p. 245),† for colorimetric tests on iron and steel. He uses several tubes of the same size and quality, having equal volumes of standard solutions of different strengths in the different tubes, and dissolves the steels for testing in similar tubes, and finally dilutes these solutions with water to the same volume as the standard solutions. By comparing these he is able at once to determine to the hundredth of one per cent. by using 1 to 2 grammes for each test. He used burnt coffee for his standard solutions, which he considered to be better than burnt sugar.

Greater accuracy in color tests may also be obtained by looking at the solutions in the tubes from above, instead of from one side. In this case, however, the bottoms of the tubes must be perfectly alike. A suitable light must be provided, and the columns in the tubes must all have the same height.

I trust that a strict observation of the directions now given will essentially remove the difficulties which have been experienced in using the color test, as well in this country as abroad. It should also be borne in mind that the properties of iron and steel are not dependent on the amount of carbon only.

Before concluding this paper I have to thankfully acknowledge the service rendered by Mr. C. G. Dahlerus, mining engineer, in working out the results now published.

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* From Mr. F. O. Söderberg, at the School of Mines, Stockholm, standard solutions, artificially prepared, as well as standard steels, are obtainable. The permanent solutions are kept in close glass tubes, to each of which belongs a corresponding burette. Those having burettes may send them to him in order to get suitable tubes for the standard solutions.

NOTES ON THE PROPERTIES OF DYNAMO-ELECTRIC MACHINES.

By Elihu Thomson.

The subject of the properties of dynamo-electric machines attracts, at present, considerable interest. Perhaps, therefore, the following observations may be of interest as exhibiting some unusual phases of their behavior. The machines with which the experiments were made were of my design and consist of an armature of spherical outline revolved between two magnet poles, constituting two nearly hemispherical concavities enveloping the armature. The field coils are two in number and surround the field cores and also the armature itself. The armature has three coils only wound upon it, and the commutator, three insulated segments of a ring, the slots between the segments allowing them to overlap, so that each segment covers over 160° of the outside circle of the commutator. A full description of this machine and its performance is in preparation. The machines experimented with could sustain from four to ten arc lights in series, at about 800 revolutions per minute.

The first experiments to be described illustrate the tendency of the magnets, which were of cast iron, to prolong the generated current even after stoppage of the machine.

Motion of about 150 revolutions per minute was given to the machine while on closed circuit, until it had charged its magnets and had shown, in consequence of a development of current, a considerable resistance to rotation. It was then suddenly stopped and immediately thereafter its circuit opened, when there appeared a small but distinct spark at the break. Other evidences of the circulation of current were obtained immediately after the complete stoppage of rotation. A smart shock could be felt by grasping the wires on each side of the break in the circuit at the time it was made.

The origin of this after-current or current after stoppage of the machine is, of course, the gradual loss of magnetism of the field-magnet cores, which induce a current in the encircling wire during the time that such magnetic change is taking place. The duration of the current is about $\frac{1}{2}$ second, but increases with the size of machine

used. The current, of course, endures only until the machine magnets have lost all except what is termed their residual or permanent magnetism.

A more curious effect, however, is produced by putting the same machine, with its bearings perfectly free and well oiled, upon closed circuit and then revolving it as before at a moderate speed. The motive power is now suddenly removed, as by quickly throwing off the driving belt. The armature of the machine in this case rapidly comes to rest and then, singularly, takes about $\frac{3}{4}$ of a turn in the opposite direction.

I have repeatedly verified this result, but do not know whether it would be obtained with other dynamo-electric machines. The armature must be very light and free. Here, again, the residuary current not only stops the machine but reacts upon it so as to work it for a moment as a motor in the contrary direction—just as if a current had been applied from a source outside the machine. What, then, is the source of this current which is able to reverse the movement of the armature? It is, as before, a current generated by and continued during the loss of magnetism of the field-magnets of the machine, and this current is, of course, in the same direction as when the machine was revolved by the applied power.

Another observation made with these machines was as follows:

A single machine driven by power was connected to two others in multiple arc, so as to drive them as motors; but these latter, although relatively nearly alike in proportion, were of different sizes—the electromotive force of one being double that of the other when driven at equal speeds. The smaller could maintain four, and the larger eight arcs in series, the character of the arcs being alike. When joined up to the first machine or generator, in parallel circuit as above indicated, both the other machines acted as motors and revolved. The speeds which they acquired, while not performing work, were, however, very unequal, and were found to be approximately in the *inverse ratio of their electromotive forces as generators when driven at an equal speed.* This observation was repeated with other sizes with results very nearly agreeing with the above statement. It would seem from the above that both machines, working as motors without retardation other than air resistance and friction, attain such speeds that the counter-electromotive forces developed by them are nearly equal and the current traversing each of them also nearly equal. The different electrical

resistances of the two machines is no doubt a modifying influence, but it seems to have little effect and, in fact, counts for little in comparison with the counter-electromotive forces developed under the conditions.

The effect of running the two machines in series as motors is very different. When so used, and with their shafts very free to turn, the larger, or one capable of producing the highest counter-electromotive force to that of the generator, alone revolves, while the smaller remains at rest. If, however, the former or larger machine be made to perform mechanical work—that is, to furnish power—its running speed is, of course, retarded and the other machine turns with a speed depending on the amount of work abstracted from its companion.

New Britain, Conn., Nov. 6, 1881.

BLAST-FURNACE HEARTHS AND LININGS.

By John Birkinbine.

Read before the American Institute of Mining Engineers, May, 1881.

The high temperatures which of necessity must be maintained to smelt iron ores require that the material forming the inside of the blast-furnace, and the bottom, should be sufficiently refractory to withstand the destroying action of intense heats, and not readily susceptible to the dissolving action of the cinder resulting from the furnace operation.

In the older furnaces sand-rocks, slates and steatites were employed, the ordinary practice being to lay a bottom of sand-rock, neatly dressed and jointed, and upon this the crucible and boshes were constructed of the same material, the shaft of the furnace being laid with slate or shale. The sand-stone bottom and crucible are at present in use in a number of charcoal furnaces, and shale inwalls are still found in this country. Professor Akerman states that in some Swedish furnaces bricks moulded from furnace slag are used in lining the shaft. The stone lining of the shaft was gradually abandoned, ordinary clay brick being sometimes substituted, but firebrick are now mostly employed. Firebrick were first used for the inwalls or the shaft, then they were used for boshes, after that they were laid in the crucible, and finally bottoms were made of them, until at present their use for lining furnaces

throughout is almost universal. The firebrick are no more refractory than some of the sandstones, shales or soapstones formerly in use, but they possess several advantages.

Large bottom and crucible stones were expensive to shape, handle and to place in position; they were often cracked or spalled by sudden changes of temperature, and, owing to the joints running through them, were more apt to permit gas, cinder or metal to work out by the crevices formed by expansion of the crucible. Firebrick, on the other hand, on account of the ease with which they are formed into convenient shapes, are more readily transported, handled and placed in position; if properly made they are not apt to crack, and, by laying them so as to break joints, few continuous crevices are formed, or if formed they are generally small. Other great advantages in the use of brick are the facility with which repairs can be made without taking out an entire wall, the possibility of using thinner walls than when stone is employed, and the construction of more shapely furnaces. Where stone was employed any considerable cutting or wear necessitated the removal of the entire work, or so much of it that the furnace had to be blown out, and in such case the complete relining of the stack generally followed. But by the use of brick and blocks from refractory clay repairs of considerable magnitude have been made while the furnace was in blast, or when blown out a few matches have restored the crucible and boshes to good condition, in which a long blast has been made. The repair of an inwall by blowing down part way, and carrying off the gases and much of the heat by means of a wrought-iron tube packed around with fine ore or clay, is not unusual,* and there are on record instances where an entire crucible has been renewed while the furnace was in blast by cutting out† sections of the old work and replacing it with new until the whole was completed.

Firebrick, as now made, are the best known material for use in the interior of a blast-furnace, and yet it cannot be said that they have fully met the requirements of the work to which they are applied. This, in some instances, is undoubtedly due to the chemical composition of the brick and their physical structure; in others it is owing to the manner of operating the furnaces. But it must be admitted that in the present state of our knowledge we have nothing which is econo-

* *Vide* Translations of the American Institute of Mining Engineers, vol. iv, p. 29.

† *Vide* Translations of the American Institute of Mining Engineers, vol. v, p. 92.

mically applicable for lining blast-furnaces which withstands the fusing and dissolving action of the heat and fluxes. It not only requires a material infusible at the temperature of molten iron, but one infusible under the action of an immense blow-pipe flame, generated at the tuyeres. At a late meeting of the United States Association of Charcoal Iron Workers a discussion took place upon the question whether firebrick crucibles could be used in cold-blast charcoal furnaces, as most of these plants still employ sandstone crucibles. Now, the fusing action in a cold-blast furnace is apparently less severe than in furnaces using hot-blast. True, the crucibles are generally small, but the pressure of the blast is very slight. Evidently, then, the indifferent success which has followed the use of firebrick in connection with cold-blast charcoal practice is owing more to the dissolving of the bricks, aided by the presence of considerable quantities of potash, on account of a poverty of flux than to a want of refractory character of the material.

Looking at the subject in a purely physical light, and disregarding any chemical action, the firebrick, if capable of withstanding the high heats without softening, should last longer in the lower zones of the furnace than in the upper, for the materials charged are much reduced in size and volume, and also softer when near the tuyeres, and the wear should consequently be much less. There are instances of long-continued furnace campaigns, but the present average blast will not reach two years. The solvent action on firebrick appears to be less appreciated than it should be, and evidently much of what is termed wear by stock is due more to chemical disintegration than loss by attrition. The most rapid driving in a blast-furnace now recorded represents a descent of stock at the rate of 8 feet per hour; and this is exceptional. A movement so slow would require an extended period to materially affect, by wear, even a soft substance; but, as the rate of descent in most furnaces is but 2 or 3 feet per hour, much of the loss charged to wear by stock seems unaccounted for by materials moving against the lining at the rate of 3 or 4 miles per annum. The throat of the furnace has often been damaged by dumping large pieces of stock against it; but, even where such is not the case, the upper parts of the inwalls in furnaces have sometimes to be renewed, owing to the gases resulting from the furnace operation acting upon the brick and destroying them.

One of the most notable instances of this was where the 16-inch wall

throughout is almost universal. The firebrick are no more refractory than some of the sandstones, shales or soapstones formerly in use, but they possess several advantages.

Large bottom and crucible stones were expensive to shape, handle and to place in position; they were often cracked or spalled by sudden changes of temperature, and, owing to the joints running through them, were more apt to permit gas, cinder or metal to work out by the crevices formed by expansion of the crucible. Firebrick, on the other hand, on account of the ease with which they are formed into convenient shapes, are more readily transported, handled and placed in position; if properly made they are not apt to crack, and, by laying them so as to break joints, few continuous crevices are formed, or if formed they are generally small. Other great advantages in the use of brick are the facility with which repairs can be made without taking out an entire wall, the possibility of using thinner walls than when stone is employed, and the construction of more shapely furnaces. Where stone was employed any considerable cutting or wear necessitated the removal of the entire work, or so much of it that the furnace had to be blown out, and in such case the complete relining of the stack generally followed. But by the use of brick and blocks from refractory clay repairs of considerable magnitude have been made while the furnace was in blast, or when blown out a few matches have restored the crucible and boshes to good condition, in which a long blast has been made. The repair of an inwall by blowing down part way, and carrying off the gases and much of the heat by means of a wrought-iron tube packed around with fine ore or clay, is not unusual,* and there are on record instances where an entire crucible has been renewed while the furnace was in blast by cutting out† sections of the old work and replacing it with new until the whole was completed.

Firebrick, as now made, are the best known material for use in the interior of a blast-furnace, and yet it cannot be said that they have fully met the requirements of the work to which they are applied. This, in some instances, is undoubtedly due to the chemical composition of the brick and their physical structure; in others it is owing to the manner of operating the furnaces. But it must be admitted that in the present state of our knowledge we have nothing which is econo-

* *Vide* Translations of the American Institute of Mining Engineers, vol. iv, p. 29.

† *Vide* Translations of the American Institute of Mining Engineers, vol. v, p. 92.

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One of the most notable instances of this was where the 16-inch wall

of the tunnel-head above the stock-line was destroyed and replaced. After lasting for but seven days, the new work had similarly failed. During this time the furnace worked badly, and when blown out was found scaffolded. It is doubtful if there is much risk of damaging the lining at the tunnel-head by gases when the furnace is working normally, and the destruction of the firebrick above the stock-line seems (as far as opportunities offered for investigation have shown) to have accompanied irregular operation.

Again, there are instances where firebrick have given out in one furnace, while others, made by the same works, and even taken from the same kiln, have proved most satisfactory. As the brick were so laid as to be practically under the same conditions as to thickness of walls and intensity of blast, we can scarcely assume that the temperature was higher in one furnace than in the other, and must, until we are able to determine to the contrary, refer the destruction to chemical action. In one instance, where such difference of behavior occurred, both furnaces were under control of capable managers expert in chemical manipulation, and were closely similar in proportions, working on similar ores, flux and fuel.

Another point in favor of the theory of chemical disintegration is the rapid loss of the bottoms of furnaces. As these are protected, except at brief intervals when casting, by a liquid bath of iron and cinder, we would naturally look for their remaining intact for a long time; but the bottom is often quickly destroyed, several feet having at times been lost in a year's work. An instance is recalled where the bottom of a blast-furnace wasted away four feet in twelve weeks. Cases could be cited where several feet of the bottom have been lost in a few hours, but this was caused by physical rather than chemical action, either from defective construction or faulty manipulation. The well of the crucible, or that part below the tuyeres, is subject to the same action as the bottom, and is often cut or wasted away rapidly. Undoubtedly, the temperature maintained naturally assists and intensifies the chemical action referred to, and the firebrick are wasted or dissolved away more rapidly, owing to the high temperature prevailing.

But, admitting the affinity of the silica of the firebrick for the bases in the charge, the question naturally recurs, Are firebrick, as ordinarily made, infusible at the temperature existing in a blast-furnace crucible? The present practice is to dispense with thick walls and use in their place thin ones, even as low as 16 inches for the crucible. Now,

if fluxing action were the only or most potent damaging force at work, the thicker the walls the better, for then there would be more to disintegrate; but we find in practice that a wall must be thin and exposed to the air, or subjected to artificial cooling for protection. This naturally points to fusion, and this view is verified by the appearance of a furnace when blown out.

It is often said that the interior of a furnace glazes in the first part of the blast, thus preserving the bricks. It may be possible that, owing to the excess of fuel, a temperature exists during the early days of a blast which forms a fusible slag on the face of the brick, infusible at the ordinary working temperature of the furnace; but it is more probable that the brick are not infusible at the ordinary heat in the furnace, and that the glazing exists only when the temperature falls below this point, as when the furnace is blown out. This may be illustrated by the ice film which forms on bricks covered with moisture when the temperature is low. The minimum thickness of brickwork for crucible walls seems to be determined; first, by sufficient stability; second, by having the walls, if possible, only so thick that they will conduct away the heat produced against the inner face so fast that that face may be kept below the fusing-point, yet without too great loss of heat from the crucible. The employment of braces binders and buckstaves permit of quite thin walls being employed,, and, as far as stability is concerned, quite thin walls are practicable. There may be exceptional cases where a comparatively long campaign has been made by a furnace without seriously cutting away its walls; but, upon the termination of a blast, the crucible and boshes are generally found much reduced in thickness and the remaining portion protected by a deposit of dust or graphite. Instances have been noted where but four inches of firebrick remained when the furnace was blown out, but this thin wall was well protected by an inner accumulation.

Recognizing the advantages gained by thin walls, efforts have been made to preserve them by extraneous means. They have been secured by a series of wrought- or cast-iron buckstaves, and jets or sprays of water have been thrown against the intervening brick masonry. They have been encased by a sheet-iron jacket, enclosing coils of pipe through which water circulated. They have been protected by cast-iron water jackets, either as hollow boxes, or containing coils of pipe, the jacket serving the double office of sustaining the crucible as well as cooling

the walls. Horizontal circles of cast iron, having water pipes cast in them, have been placed around the crucible and boshes at intervals in the brick-work, and coils of pipe have been built into the walls. The success which has attended these efforts demonstrates that, to hold the crucible and bosh walls, artificial cooling must be resorted to.

The manner of constructing the masonry, and the character of the brick and clay employed, all affect the life of a furnace. The use of furnace blocks, tiles, or ordinary 9-inch fire-brick, each have their advocates; but a furnace lined with the best brick is imperfect unless the clay forming the joints is fully as refractory as the bricks which it unites. If joints are opened, either by the clay being more readily melted or fluxed out, or by not having sufficient non-shrinking material to preserve them, a greater surface of each brick is exposed, and the destruction is consequently more rapid. Excessively thin clay often causes defective joints, owing to the evaporation of the water leaving void spaces.

It is surprising that monolithic hearths and crucibles have not grown in favor in this country. They are employed in other countries, the Swedish practice being to use sandstone or a mica schist ("stallsten"), and place within this a lining composed of crushed quartz, held together by one-eighth to one-tenth of fire-clay, the mass being thoroughly rammed about appropriate forms, so as to give the desired shape and size to the crucible and boshes.

What has been said in reference to the imperfections of fire-brick can be applied with equal force to other metallurgical operations besides the smelting of iron ores in a blast furnace, but this paper has been confined to a few physical features bearing upon the problem. Much has been written as to the chemical composition of refractory materials, and considerable interest was manifested by the Institute in the subject in 1875 and 1876. Mr. Holley, then president, in his address at the Cleveland meeting, in October, 1875, called attention to the necessity of a better refractory material, and showed the cost per ton of product in various works for fire-clay, bricks, etc. A committee was appointed to report upon the subject, and Professor Egleston, as chairman, contributed a paper which covers much of the present knowledge on the subject. This is ably supplemented by the researches of the Geological Survey of New Jersey, and the complete analyses of prominent fire-clays embodied in the special report of Messrs. Cook and Smock. Some experiments to test the refractory character of fire-brick of

various makers were made, under the direction of the Geological Survey of Pennsylvania, in a small shaft furnace, in which it is claimed a heat sufficient to melt steel was maintained. Unfortunately, the experiments were too much restricted, both in time and number, to give reliable results; but, though limited, they are a valuable contribution to our knowledge of fire-brick, as far as their action in the presence of incandescent fuel only is concerned. Although the tests did not not in any case last longer than two hours, all the bricks experimented upon were cut or cracked, some standing much better than others.

The necessity of a better material for metallurgical processes is surely no less important now than in 1875–76, and this paper has been prepared more to revive interest in the subject than to present any novel statement, or to enter into an investigation of the proper chemical and physical composition of fire-brick. The manufacturers of fire-brick have shown a commendable desire to meet the demands of metallurgists as to shape and form, and considerable attention has been bestowed upon composition; but most of these experiments have been limited by individual enterprise and capital. A thorough investigation of the physical and chemical features of fire-brick, in connection with a consideration of the circumstances under which they are to do duty, will undoubtedly prove of immense value to practical metallurgy.

Electric Lights.—In concluding his report upon the different systems of lighting which were exhibited at the Paris Exposition Du Moncel says that the systems of incandescence are already numerous, and doubtless many others will soon be added. Most of them differ from one another only by the composition of the incandescent carbon and its mode of fabrication. It is impossible to base any correct judgment upon the more or less brilliant aspect of the lamps, for, as they are fed by electric generators of very different intensities, those which have the strongest currents naturally furnish the most brilliant and the whitest light. It would therefore be imprudent to pronounce in favor of any single system until a serious examination and comparison has been made by a commission of disinterested scientific men. There is, however, reason to hope for a satisfactory solution of the problem of household illumination by electricity.—*La Lumière Electrique.* C.

SAND FILTRATION AT BERLIN.

By Prof. Wm. Ripley Nichols.

Up to the present time there has been very little done in this country in the way of systematic filtration of water supplies, partly, perhaps, from indifference and lack of information, but mainly on account of the expense. The numerous complaints which arise in the case of almost every city and town supplied with surface water render the question of filtration an important one for the immediate future, and any engineer who has to do with the planning of water works is liable to be called upon to estimate the cost of filtration and to state how far it may be expected to overcome anticipated or existing evils. For this reason, details of the practice in well-managed works, where the conditions are similar to those which obtain with us, are of peculiar interest. Such details are given in a pamphlet recently published by the superintending engineer (Betriebs-Ingenieur) of the Berlin filtration works.* The pamphlet also contains the results of observations on "natural filtration" in the neighborhood and elsewhere.

A very considerable portion of the city of Berlin is still supplied with water from the dirty and sluggish Spree after it has been subjected to a very thorough filtration. The water is taken from the river directly on to the filter-beds, and although the sluggishness of the flow would allow the deposition of much suspended matter, the very considerable water traffic between Berlin and Köpenik, past the water works, keeps the water in a roily condition. Furthermore, the Spree receives, above the point from which the supply is taken, the waste-water of a number of factories, among which are dye- and print-works; it also receives the effluent of a sewage farm mixed, in some cases, with sewage itself. Besides being thus contaminated, the water, especially in time of flood, possesses a deep brownish-yellow color and, at times, a peculiar *pondy* taste due to vegetable extractive matter. Moreover, from spring until fall, a more or less copious growth of *algæ* adds to the disagreeable character of the water.†

* Mittheilungen über natürliche und künstliche Sandfiltration. Nach Betriebsresultaten der Berliner Wasserwerke vor dem Stralauer Thor, bearbeitet von C. Piefke, Betriebs-Ingenieur. 8vo, pp. 75. Berlin, 1881.

† These *algæ* I have found, by personal observation, to be identical with those

The filtration works now supply daily about 40,000 cubic metres (in round numbers 10½ million U.S. gallons) of filtered water—in summer often a larger quantity. There are eleven filter-beds—three covered and eight uncovered—having a total area of 37,000 square metres (about 400,000 square feet). The beds are constructed on the English model, fine sand at the top and coarser material below.* With the large area at disposal it is possible to carry on the filtration at a very slow rate. The water is used, of course, in varying quantities from hour to hour, and, on account of the small size of the clear water reservoir, a constant rate of filtration is impossible; the maximum rate is, however, not over 0·1 metre downward per hour. For the greater part of the time 1 square metre of sand surface is not required to furnish much more than 1 cubic metre of water in twenty-four hours. This would be at the rate of only 24½ U.S. gallons per square foot, and very much less than is the practice elsewhere.† The filtration takes place under a very slight head, seldom of more than 0·5 metre (say 20 inches), but even with this low pressure and slow delivery it has been found impossible, with clean sand alone, to filter the water satisfactorily. If the unfiltered water be allowed to stand a fortnight or so, although the larger of the suspended particles will have settled to the bottom, the water still retains a milky appearance, and sand alone cannot remove the exceedingly fine particles to which this appearance is due. On this account, the water from a freshly cleaned filter is not used at once, but is allowed to stand on the bed and then passed through very slowly until a thin coating has formed on the surface of the sand. This coating is essential to the removal of the finest particles from the water subsequently filtered. Of course, as the coating becomes thicker the filtration becomes more difficult until it partially stops and the filter is "dead."

As has been hinted above, the great trouble in summer is from the abundance of small *algæ* which soon clog the filter. When the *algæ* are absent, a square metre of surface usually filters 20 cubic metres before cleaning is necessary, but in summer the capacity is not over

which occur in our own ponds and which have given much trouble in some of our water supplies, as, for instance, at Springfield and Boston, Mass., and at Albany and New York.

*See Kirkwood, Filtration of River Water. New York: Van Nostrand, 1869. Nichols, Filtration of Potable Water. New York: Van Nostrand, 1879.

†The *maximum* rate, given above by Piefke as 0·1 metre downwards per hour, would be at the rate of nearly 60 U.S. gallons per square foot of surface in 24 hours.

10 cubic metres to the same area. Sometimes the meteorological conditions are such, especially late in the season, that the *algæ* enter into decay and form a peculiar slimy and almost impervious coating over the surface of the sand so that it becomes impossible, under the pressure commonly employed, to pass more than 2 cubic metres of water through 1 square metre of sand surface. This decomposition of the *algæ*, as described by Piefke, has often been noticed in the ponds and reservoirs of the Eastern and Middle States, and the very particular observations which Piéfke gives on this point are well worth the the attention of any who are called upon to consider the question of filtration in this country. We may note the fact that, under the conditions just referred to, the superiority of the covered beds became very evident. As has been observed in this country, the decay of *algæ* increased very much the amount of ammonia (of "albuminoid ammonia") and of nitrites and nitrates. A rather curious observation was made in the decomposition of the *algæ* on the open filter-beds. The gaseous products of decay collected in bubbles until these were sufficiently large to break through the slimy coating and rise to the surface. In the hot days of August this evolution of gas was very considerable, and, as a result of this piercing of the coating, a "dead" filter was sometimes brought again into activity; when such a filter was cleaned the little cavities in the sand thus produced were clearly defined, filled, of course, with accumulated dirt.

The *algæ* are not to be regarded as an unmitigated evil. Besides making the removal of the finer portions of the sediment possible,* in their growth they are purifying agents; they change at least a part of the dissolved organic matter into insoluble substances which settle to the bottom and can be removed by filtration. It is, however, desirable that the water should not remain in contact with them after they have begun to decay.

If, after filtration, the apparently perfectly clear Spree water is allowed to stand for eight or ten days, green *algæ* develop themselves, which is probably due to the fact that the spores of the plants are not retained by the filters. This fact, however, is of no practical consequence in the case of the Spree water, for the water is consumed long

*The difficulty, which experiments have shown to exist, in obtaining by sand filtration a clear and bright water from some of our Western and Southern streams, which are charged with clay, is probably greater than it would be in the presence of suspended vegetable matter, which in itself would be considered an objection.

before the spores have had time to develop. This is not the case with all waters, as has been found by experience in the works which supply another portion of Berlin. The "ground water" of the Tegel supply contains an *alga*, the *crenothrix polyspora*, of such rapid development that filtration would not be of much use, as the unremoved spores would develop in the service pipes before the water was consumed.

As has been mentioned, the Spree water often possesses to a marked degree the brownish-yellow color common to streams which flow through marshy or peaty regions and to the water of most impounding reservoirs. This color, with the taste which at times accompanies it, gives rise to general complaint,* but even very slow filtration fails to remove it to any considerable extent. Filters of finely prepared cellulose remove a large proportion of the color, but are hardly practicable on the large scale. If sand filters have a slight action in this direction, it is to be ascribed rather to the sediment containing vegetable fibre than to the sand itself.

A few practical details of management may be of interest. In the Berlin beds the thickness of the sand is 600 millimetres (about 2 feet). At each cleaning the sand is removed for a depth of about 10 millimetres, but fresh sand is not returned to the bed until only about 200 millimetres of the original thickness remain. The foul sand is allowed to stand exposed to the air until, by decay, the organic matter has lost its slimy character; it is then washed and eventually replaced upon the beds. When the filters are emptied the water is drawn completely off, and by successive and systematic stirring nearly the entire thickness of the sand is exposed to the air in order that the small amount of organic matter which was not retained at the surface may be oxidized and destroyed. With the same object in view, the air is allowed to circulate freely, for several days if possible, through the coarser underlying material. The filters are filled from below with filtered water, and then the water is passed through slowly and is allowed to waste for several days.

Artificial filtration is, on the whole, not a difficult operation, but it is one in which the details must be conscientiously and intelligently attended to, and there is no room for negligence or false economy. That the beds must be often cleaned, that from time to time a few thousand cubic metres of filtered water must be used in refilling the beds: these are matters of no consequence if it is thereby possible to

* This, too, is an American experience.

reach the main object in view—namely, the furnishing of a good water. The place for economy is in the choice of the cheapest way of carrying on the various details of the works.

Piefke also describes experiments on the use of iron as a purifying medium as a preliminary to sand filtration, but the experiments did not awaken hopes that iron could be used advantageously on the large scale.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON GRISCOM'S ELECTRIC MOTOR AND BATTERY.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, January 8th, 1881.

The Sub-committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred, for examination, Griscom's Electric Motor and Battery, report that a meeting was held at the residence of the inventor, Mr. William W. Griscom, on December 14th, 1880, when the apparatus was exhibited and operated as a motor for an ordinary No. 8 Wheeler & Wilson sewing machine.

A second meeting was held at the Hall of the Franklin Institute, on December 28th, at which time two motors were carefully examined by the committee.

A number of queries in relation to the novel features claimed for the apparatus, and their possible practical value, had been submitted to the inventor; these, together with his replies thereto, were read and considered.

Members of the committee have also informally visited the laboratory of the inventor for the purpose of witnessing the operation of the motor under varying conditions, and to make such tests as lay within their power.

The mechanism may be described as follows:

The motor consists, briefly, of two semi-circular electro-magnets which together form a ring; their poles project inward and, together with the wire coils, form a cylindrical tube within which a Siemens armature revolves.

The poles extend laterally beyond the ring, forming supports for the brackets which carry the bearings of the armature and the brushes of the commutator. In order to reduce the wear of the journals to a

minimum, the bearings are made four times the diameter of the shaft, and the direction of the wear is away from the point of nearest approach, so that the poles of the armature and magnets can never come in contact from this cause; a frequent source of annoyance and danger in former motors.

The friction wheels of the brushes are in pairs and the shape of the commutator is such that one wheel will always touch one-half of the commutator before its companion leaves the other.

The tension of the belt is readily adjusted by means of a fork which carries the motors.

The battery consists of six one-gallon cells, into each of which plunges a plate of zinc 4 inches long and 2 inches wide and two plates of carbon exposing a like surface.

The large amount of liquid (electropoion) is merely to save the trouble of frequently recharging; a battery containing six drachms per cell gives equal power but for a shorter period. It is estimated that the battery once charged will continue to supply the motor with sufficient power for all ordinary use of a sewing machine in a private family for many months, or probably one year, without refilling. It is inclosed in a tight box which, covered with a cushion, serves as a seat for the operator. The method of automatically removing the plates from the solution when not in use will be found described elsewhere in this report.

In the course of this investigation, certain seemingly novel and certainly interesting theories relating to this subject were elicited from the inventor; but, as this report is designed to be a simple statement of observed facts, the committee would recommend that a special committee of experts in electrical science be appointed to thoroughly explore and decide upon the merits of these purely theoretical considerations.

The inventor, in his application (No. 1188) dated November 23d, 1880, to the Committee on Science and the Arts of the Franklin Institute, wrote as follows:

"Gentlemen.—You are respectfully requested to examine into the merits of and report upon Griscom's Electric Motor and Battery. Your attention being more especially invited to the power of the motor in proportion to its size, its simplicity of construction, its mechanical details and its adaptability to general use, and also to the method of

graduating the current from the battery and other peculiarities, rendering it a safe and suitable battery for household use."

The committee, having made a careful examination of all of these points, begs leave to report upon them *seriatim* as briefly as possible.

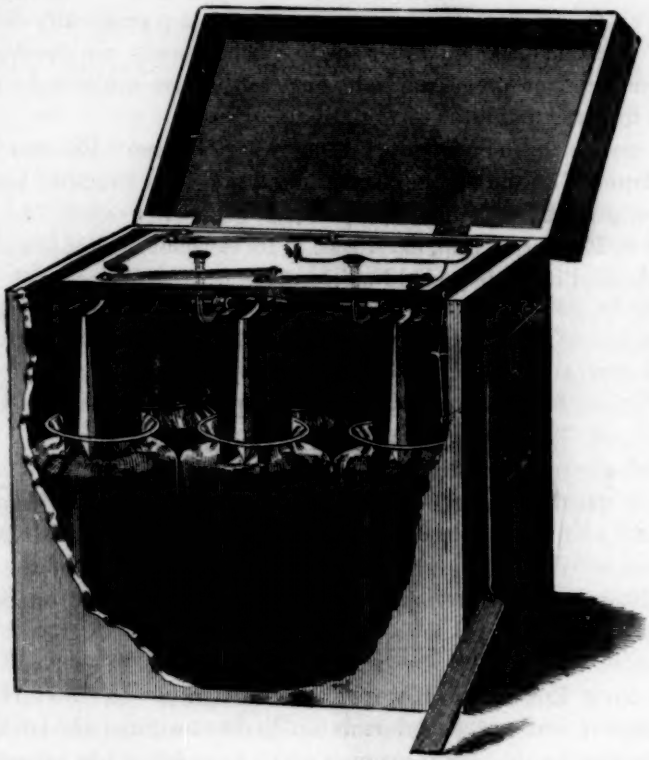
First. Power.—The power of the motor depends upon the quantity of electricity furnished by the battery; this is easily regulated by raising or lowering the zinc and carbon plates in the exciting fluid. It was found that when the plates were but partially plunged in the bath, sufficient mechanical power was developed by the motor for all ordinary requirements of a sewing machine, and when fully immersed it was more than sufficient to drive a large needle through sixteen layers of cotton cloth at a very rapid rate.

Second. Size.—The size of the motor is $2\frac{1}{4}$ inches in diameter and 4 inches long and its weight is but $2\frac{1}{2}$ pounds; it is securely attached by a light frame to the table of the sewing machine.

Third. Construction.—The entire apparatus appears to be simple in its construction, excellent in all its mechanical details, and its adaptability to general use is not questioned by the committee.

Fourth. The Battery.—This differs from the ordinary Grenet form mainly in the automatic arrangement for removing the plates from the bath and in the large size of the cells, holding one gallon of "electropoion" fluid each. The method of graduating the strength of the current, and consequent speed of the motor, is as simple as it is effective. A very slight pressure of the foot on the treadle suffices to start

the machine as gradually as may be desired; the speed may then be increased up to one thousand or more stitches per minute which, it is said, is considerably faster than is now attained by professional sewing women, while others seldom sew more than 300 to 400 stitches per minute.



Two forms of the battery were shown, in both of which the plates are automatically raised above the bath when not in actual use. In one form this is accomplished by means of a spiral spring attached at either end of the bar to which the plates are permanently fastened. In the other a similar result is attained by means of a counter weight on the small arm of the lever attached to the treadle.

It would seem to your committee that the important novel feature in this battery consists in the size of the cells, which thus enables it to continue operative, without recharging, for a great length of time. As the current is necessarily intermittent when the motor is running, and

as the plates are frequently raised and lowered by the operator to accommodate the needs of the work of sewing, the main objection to the ordinary Grenet battery, viz., the rapid deterioration when a constant current is required, is avoided to a great extent, while its advantages for household and occasional use are retained. These are as follows: It generates no gases or vapors "that are practically deleterious;" the zinc elements do not, as in other batteries, require frequent amalgamation or attention, and when not in use are simply raised above the fluid and allowed to drain.

In conclusion, the committee recomends "Griscom's Electric Motor and Battery" to the favorable consideration of the Franklin Institute as an apparatus possessing great power in proportion to its size, simplicity in its construction, excellence in its mechanical details and general adaptability to household use.

ALEX. E. OUTERBRIDGE, *Chairman.*
E. ALEX. SCOTT.
ROBT. B. HAINES, JR.
ADDISON B. BURK
N. H. EDGERTON.

At a stated meeting of the Board of Managers of the Franklin Institute held November 9, 1881, the Elliot-Cresson Gold Medal was awarded to William Woodnut Griscom for his invention of the Electric Motor, upon the recommendation of the Committee on Science and the Arts.

Various Effects of Magnetic Armatures.—In 1863 Hughes undertook a series of experiments which demonstrated the advantage of armatures for the electro-magnets which he employed in his printing telegraph, but the question was not studied generally. Du Moncel has therefore undertaken a variety of experiments, and he has found that the effects may be diametrically opposite, according as the magnets act only by one pole or by both. In the former case there is generally a disadvantage, in the latter an advantage. The effects also vary with the relations which the armatures bear to the inter-polar interval. In an ordinary electro-magnet, with two armatures, which may be placed at any required distance from each other, the greatest effect is generally found when that distance is about one-fourth of the inter-polar distance.—*La Lumière Electrique.* C.

THE SCIENTIFIC PRINCIPLES INVOLVED IN ELECTRIC LIGHTING.

By Prof. W. Grylls Adams, F.R.S.

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(Continued from page 375.)

With Gramme Machine.

In Auerbach and Meyer's experiments for 800 revolutions a minute, the maximum electro-motive force is 76 volts and for 51 volts, or two-thirds of the maximum value, there is a current of 6·5 webers through a resistance of 7·8 ohms. Below this value the current is unsteady. With Siemens' machine, a speed of 700 revolutions a minute gave a maximum electro-motive force of 76 volts, and for 51 volts there is a current of 15 webers through a resistance of ·6654 ohms. With a small Siemens machine, a speed of 1000 revolutions per minute gave a maximum electro-motive force of 42 volts, and for two-thirds of this, or 28 volts, the current was 11·2 webers through about 2·2 ohms resistance.

Dr. Hopkinson has investigated the way in which the electro-motive force in a Siemens machine depends on the current. He has shown that:

1. The electro-motive force is, for a given current, proportional to the speed of revolution of the armature.

2. That the electro-motive force does not increase indefinitely with increasing current, but,

3. Only increases in the direct ratio as the current increases up to about two-thirds of its maximum value.

The current is very unstable for small change of resistance, or of speed of engine, as long as the value of electro-motive force is less than two-thirds of its maximum value. There is a remarkable difference in the ratio $\frac{E}{C}$, depending on change of speed from 600 to 700 revolutions a minute, where the current changes from 5 to 15 webers, for this increase of one-tenth of the speed.

As regards the relation of work converted into electrical energy to

the work expended to produce it, it appears from the experiments of Mr. Schwendler and Dr. Hopkinson that, with the Siemens machines employed by them, the loss of power was from 12 to 14 per cent., so that if the external resistance of the circuit, *i. e.*, the electric lamp, etc., be so adjusted that half the total work produced appears in the arc, then 43 or 44 per cent. of the total work expended is produced in the arc.

The results arrived at by Dr. Siemens, with his latest machine on Wheatstone's principle are: 1. That the electro-motive force, instead of diminishing with increased resistance, increases at first rapidly and then more slowly towards an asymptote. 2. That the current in the outer circuit is actually greater for a resistance of 1½ ohm than for one ohm.

With a current of 30 or 40 webers, the horse-power expended was 2·44 h. p., and the effective work 1·29 h. p., giving an efficiency of 53 per cent., as compared with 45 per cent. in the ordinary Siemens machine. The maximum energy which can be converted into heat in the machine is 1·3 h. p. The new machine will give a steadier light with greater economy, and may be driven by a smaller engine.

The Brush Machine.

Among the latest continuous-current machines are two which promise to be very successful machines. The Brush, with a ring on the Gramme system, with eight divisions or portions hollowed out to receive the coils, the bobbins at opposite ends of a diameter being connected together and to a commutator. When a pair of bobbins passes the neutral point, so that there is no current in it, it is put out of circuit for one-eighth of a revolution, so that the current produced in the other bobbins is not wasted, by being sent through the resistance of the two which are producing no current. On the inducing magnets are wound fine wires, offering considerable resistance, which carry the current when the external circuit is open and keep up the magnetism; but when the circuit is closed, the thick wires on the magnets carry the principal part of the current.

The internal resistance of the machine being about 10½ ohms and the external resistance 73 ohms, there was, according to calculation, a current of 10 webers and an electro-motive force of 839 volts. With these numbers, the effective work on the external circuit ought to be

87·36 of the whole electrical work produced; but, practically, it is only 61 per cent.

This relation of work converted into electricity to the work expended in this machine, is about 73 per cent., whereas with both Gramme's and Siemens' machines, with relatively smaller external resistances, this ratio is about 88 per cent.

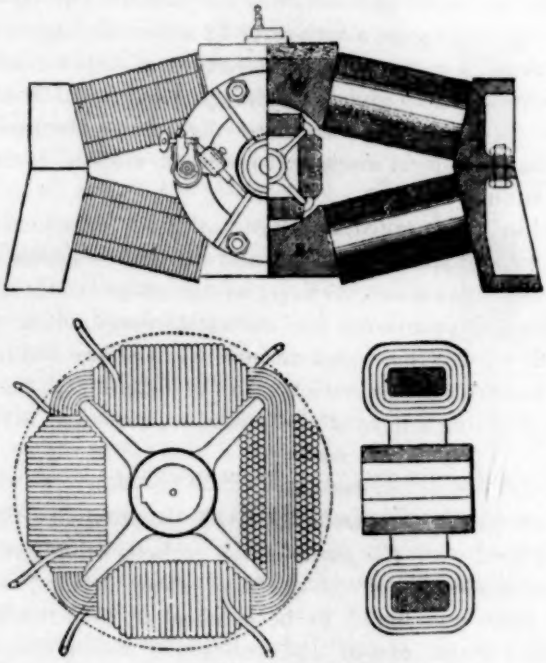

Fig. 5.—The Bürgin Machine.

Another continuous-current machine is the Bürgin machine, from Switzerland, which has only just been introduced into England by Mr. Crompton. Four or six coils are wound on the sides of a square or hexagonal frame, consisting of iron wires. The corners of the frame come very near to the poles of the magnets. There are six or eight of these frames arranged successively in the form of a helix. The action is similar to that of the Gramme machine, the dynamo-electric principle being introduced in this as in other machines. The construction of the machine is very simple, and its efficiency has been proved by M. du Moncel and also by Mr. Crompton to be remarkably good. These machines are of small internal resistance, and are driven

at high speeds (up to 1600 revolutions a minute), so that there is considerable electro-motive force.

The efficiency of certain Gramme machines, exhibited by Mr. Crompton and tested at the Glasgow Electric Light Exhibition, was shown to be such that, with a power of 4 h. p. expended in producing the current, only $\frac{1}{2}$ h. p. was expended on friction and passive resistances, so that about 88 per cent. was net power. This $3\frac{1}{2}$ h. p. converted into electricity gave a current of 32 webers through a resistance of about 2 ohms, *i. e.*, an internal resistance of 1·077 ohms, and the arc of a Crompton lamp giving a light equivalent to 2158 candles.

Now, we may compare with these the results obtained by Mr. Crompton for the Bürgin machine, running at a speed of 1675 revolutions per minute.

Five machines were tested, and the total work expended was 5·45 h. p. The amount spent on friction and passive resistances, when the circuit was open, was about ·25 h. p., so that about 86 per cent. is net power. The work converted into electrical energy, 5·2 h. p., gave a current of 20·15 webers through an internal resistance and conducting wires of 2·8 ohms, together with the arcs of 3 Crompton lamps (about 5 ohms), each giving a light of 2103 candles, measured horizontally; the electro-motive force $= \frac{\text{work}}{\text{current}}$ being equivalent to 163 volts.

With photometric measurements made horizontally, the electric light being level with the gaslight, the carbons being concentrically adjusted, and the length of the arc being about 3 m.m., the greatest amount of light was found to be obtained at 1675 revolutions per minute, with 3 lamps, each of 2103 candles, or with 4 lamps, each of 1246 candles. The upper carbon was 10 m.m. and the negative carbon 13 m.m. in thickness. The consumption of the upper carbon was 4 c.m. and the lower nearly 2 c.m. per hour. The total horse-power expended was 5·55 h. p., and the current, with 3 lamps, varied from 18·36 to 21·94 webers, and with 4 lamps, from 16·9 to 19·6 webers. All three lights were very steady and much whiter than the single lights of Gramme's machine.

Mr. Crompton has been kind enough to lend me, this evening, a new Bürgin machine, about which he gives me the following facts: It was tried at 1620 revolutions a minute, and a current of 28 webers was sent by it through 3 lamps, in series. When the arcs were lengthened to one-fourth of an inch each, the current was 24 webers,

and the arcs gave a light of 5000 candles each, the photometric measurements being made in the most advantageous direction.

The British Electric Light Company have been good enough to place at my disposal, for this evening and for my lecture next week, two Gramme machines for trying some of the electric lamps which have been kindly lent to me.

These machines are driven by a steam engine lent by Messrs. Robey, of Lincoln, and for the Brockie and other electric lamps I am indebted again to the British Electric Light Company, to Dr. Siemens, to Mr. Crompton; to Mr. Latimer Clark for the Lontin lamp; for the Rapieff and Wilde electric candle, to Mr. Berly; to the Jablochkoff Electric Light Company for their candles; and to the Anglo-American Light Company for the Brush lamp.

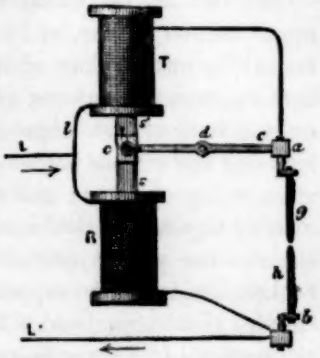

Fig. 6.—Siemens' Differential Lamp.

The Brockie Lamp.

The upper carbon is attached to an iron tube, which passes into a solenoid, through which it passes as the positive carbon burns away. The solenoid forms a shunt or by-pass for the arc, and takes a small part of the current and holds up the iron tube which carries the upper carbon; as more current passes through the coils, the motion of the carbon is stopped.

A commutator is so arranged and driven by the dynamo machine as to break the current and allow the carbons to come in contact for an instant at regular intervals, say every minute. Then the circuit is completed again, the upper carbon is drawn to its proper distance apart, and the light continues. At every minute the light goes out, but instantly relights, and no variation of light is perceived.

Siemens' Differential Lamp.

A thick-wire bobbin (T) carries the arc current, and another fine-wire bobbin (B) forms a shunt to the arc. The interval between the bobbins equals the height of each of them. The iron rod *s s'* is of twice the length of each bobbin, and its ends in the normal position are at the centres of the bobbins. The attraction by the thick-wire

bobbin tends to lengthen the arc and diminish the current, and so its attraction is weakened and the arc is again diminished, the attraction on the iron being regulated by the change of resistance in the arc. A pendulum arrangement is attached to prevent the oscillations of the carbon from being too sudden.

Crompton Lamp.

The carbons are brought together by means of the weight of the upper carbon holder, as in the Serrin lamps. The carbons are controlled by means of an electro-magnet, of which the principal armature separates the carbons, and a light secondary armature is arranged on the back of the large one, and does the more delicate work of bringing the carbons together. The large armature supports the negative or lower carbon; and when the small armature has brought the carbons together, so that a current passes, the large armature separates them to the proper distance apart for a good light. When the arc is broken, the armature, supported by a spring, is raised, and brings the carbons into contact, and relights the lamp. The small variations in the strength of current react on the second armature, which is held at some distance above the large armature by a light spiral spring. The small armature carries an arm, which is applied as a brake wheel, which is the last wheel of a train of wheels set in motion by the weight of the positive rod.

Regulator in Brush System.

A very pretty arrangement for shunting the current past a lamp (when it is not in use), so that one lamp may be put out without affecting the other lamps in the circuit, is adopted on the Brush system.

The current passes through a solenoid coil, wound with thick wire, and then passes to the upper carbon, through the arc to the lower carbon, and then by the frame to the next lamp. The solenoid holds up a rod of iron, which tilts a ring on one side, through which the carbon passes, and so locks it. To the end of a thick wire of the solenoid is attached a thin wire (150 ohms), which is also wound on the solenoid, and which forms a shunt or by-pass to the arc, taking more and more of the current as the resistance of the arc increases. This thin wire is wound the opposite way, and the current in it relaxes the hold on the carbon, so that it falls slowly, and then takes more of the current. As soon as it does so it is again held fast. To prevent

the carbon from falling too rapidly it is passed through a vessel containing glycerine, and slides downwards very slowly. The current through the thin wire also passes through another solenoid, which forms a shunt or by-pass to the whole lamp, so as to take all the current past the lamp if it should get out of order. When a considerable current flows by this path—*i. e.*, if the arc becomes an inch long, so that its resistance is greatly increased—the second solenoid draws up a piece of iron, which lets all the current pass, and the lamp is thrown out of the circuit.

In the Brush lamp, which is designed to burn 16 hours, there are two pairs of carbons, with the rings on the upper carbons, which hold them by friction, so adjusted that one is held about one-fourth of an inch above the other, and, therefore, the second carbon will not come into action until the first falls or is burnt out.

All the electric candles, such as the Jablochkoff candle, the Jamin candle, the Wilde candle and the De Meritens candle, consisting of three carbons, are fed by means of alternate current machines, because it is essential that the two carbons should burn away equally. In the Jamin and the Wilde candle the carbons are at first in contact, but when the current passes one of the carbons is separated from the other, because its holder is set on a hinge, so as to be acted upon by a small electro-magnet through which the current passes.

M. Joubert has found that it is necessary, in order to keep the arc steady with the Jablochkoff candle, that the alternate current in the circuit should have a mean value of eight or nine webers, and that below five webers the arc cannot be kept alight; between the bases of the two carbons forming the candle there is an electromotive force of 40 or 45 volts. The Jablochkoff candle uses up about 66 kilogrammetres of work, of which 33 kilogrammetres, or 4·6 h. p. is converted into heat and light.

When the arc is produced in a magnetic field, either by disturbing it by an electro-magnet, or by placing a frame around it, as in the Jamin candle, it is necessary to have a current half as large again as when the electro-magnet is not in action. One-third of the energy of the current is in such a case spent in producing a strong magnetic field around the electric arc, and is, therefore, so much wasted energy, as far as the electric light is concerned.

When gas was first introduced extensively for lighting purposes, many objections were raised to its use, and among them was one which

was recorded by Clement Desormes, in 1819, which is summed up in the following quotation:

"The light is of a disagreeable yellow color, entirely different from that red and warm gleam of oil lamps; it is of a dazzling brightness; its distribution will be impossible and irregular, and it will be much dearer than oil lighting, and, even if it should be improved, it will still remain much dearer than those lights which we already possess."

Just as Desormes had become accustomed to the red gleam of oil lamps, and objected to the coldness of the yellow gas light, so, a year or two ago, a similar objection was raised against the electric light, that it was entirely different from the yellow and warm gleam of gas-light; that it is of a dazzling brightness; that its distribution would be impossible and irregular; and that our streets would be left in darkness.

These objections do not seem to be so strongly taken up by the public as they were two years ago, for they have seen several trials of the electric light; and, although there are many difficulties in the way, yet the fact that the electric light has all the colors more uniformly blended, and is, therefore, a whiter light than gas, and enables objects to be seen in their true colors, can hardly be urged any longer as an argument against its use. The same argument might be urged for the same reason against bright moonlight, or against the light of day, and in favor of the yellow London fog. The Kyrle Society, in its search after truth and beauty, must surely be strong supporters of the spread of the electric light.

If we return to the Report of the House of Commons, we find the following statement:

"A remarkable feature of the electric light is that it produces a transformation of energy in a singularly complete manner. Thus the energy of 1-horse power may be converted into gaslight, and yield a luminosity equal to 12-candle power. But the same amount of energy transformed into electric light produces 1600-candle power."

The experiments of Mr. Schwendler, of Dr. Hopkinson, and of others, have shown that, both with the Siemens machine and with the Gramme machine, 88 per cent. of the total work expended is converted into electrical energy. Theory has established that, if the external resistance of the circuit is equal to the internal resistance of the battery or magneto-machine, the available work in the external circuit is a maximum.

Suppose, then, that we have 40 Grove's cells, each of ·25 ohms resistance, and of an electro-motive force of 2 volts, the external resistance being 10 ohms—

$$\text{Then } Q = \frac{E}{R + r} = \frac{40\,E}{40 \times \cdot 25 + 10} = 4 \text{ webers,}$$

$$\text{and } EQ = 2 \times 4 \times 40 = 320.$$

The work done in the external circuit is $\frac{320}{9{\cdot}81 \times 2} = 16$ kilogram-metres per second nearly, or about $\frac{2}{3}$ h.p.

A small Gramme machine of the A type, having an internal resistance of 4·58 ohms, and with an external resistance of 4 ohms, gives an electric current of 17·5 webers and an electro-motive force of 158·5 volts, giving an amount of work equivalent to 2 h.p., $EQ = 160 \times 17$ nearly $= 8$ times the energy of 40 cells of Grove.

If we wished to replace such a machine by Grove's cells, we should have to arrange about 80 cells to get the same electro-motive force, and to make each cell about four times as large, or to arrange 320 cells in four sets of 80 in each set, to get the same amount of external work done as by the Gramme machine. This will show how impossible it is to do the work by voltaic batteries which can be done by magneto-electric machines.

The equation, work $= EQ$, may be satisfied in two ways—either by making Q large and E small, *i. e.*, making what is called a quantity machine which will only do effective work when the external resistance is small; or we may make Q small and E large, *i. e.*, what is called a tension machine, which requires an external resistance large enough to prevent the machine from being overheated, and to satisfy the relation for the greatest amount of external effective work.

Comparison of Two Gramme Machines.

	Quantity.	Tension.
Number of turns per minute,	797	967
Internal resistance,	1·2	4·58
External resistance,	1·14	4·00
Current in webers,	29·67	17.51
Electro-motive force in volts,	81·58	158·50
Work spent to produce current,	243	277

Thus we see that the total amount of energy is nearly the same in the two cases, but in one case it is spent in driving a large current through

a small resistance, and in the other a smaller current is sent through nearly four times the resistance, and to do this a higher electro-motive force is required. This higher electro-motive force is obtained by increasing the number of turns of wire in the bobbin and in the magnet, so strengthening the magnetic field, and also by increasing the number of turns of the machine.

We arrive, then, at the conclusion that, to overcome higher resistances more effectually, higher electro-motive force, and therefore higher speed is required. Now our resistances may be so high that an ordinary current of electricity, even from a dynamo-machine, will not pass through it, in which case we have to resort to another method of producing electricity, of still higher electro-motive force, but the quantity produced is then considerably diminished. We have then to take an induction coil, consisting of two coils, in one of which a current of electricity from a battery is passing, and by suddenly breaking and making this current, to obtain great changes of the magnetic field, and hence great electro-motive forces, and so get very powerful alternating currents. We know the effect of checking suddenly the flow of water in a pipe. Sometimes the increase of pressure so produced may be sufficient to burst the pipe, and this is one transformation of the energy of motion of the water. This is analogous to the development of the energy of the induction current by the sudden checking of the electric current in the primary circuit. Water may be raised to a high level by a series of sudden impulses, as in the hydraulic ram. A flow of a considerable quantity of water being suddenly stopped, there is at once a sudden increase of pressure, which is sufficient to lift a valve, and allow a small quantity of water to pass into the reservoir or air-chamber. This air-chamber regulates the action of the flow of water up the pipe from the reservoir, just as the resistance and capacity of the secondary circuit regulate the secondary induction current when the primary current is broken. The action of the induction coil is very well illustrated by the action of the hydraulic ram, the level to which water is raised corresponding to the electro-motive force of the secondary circuit. Just as in the hydraulic ram, the quantity of water raised by the machine is at the best only about 66 per cent. of the quantity used, so in making use of the induction current to do work, or to produce the electric light, it is impossible to convert more than a fraction of the energy of the original current into useful work.

In the two systems of electric lighting to which I wish to draw

special attention this evening we have instances of the two opposite methods of accomplishing the same end, viz., the lighting of moderate-sized rooms by a steady and pleasant light.

The Werdermann or Joel Electric Light.

In the Werdermann system, or the Reynier system, a small thread or point of carbon abuts against a plate or edge of carbon or of copper, and becomes heated by the current so as to give out a glowing light, and gradually consumes away, but more and more slowly as the carbons are are more and more improved. In these lamps, kindly lent to me by Mr Latimer Clark, and in these Joel lamps kindly lent to me by Mr. Joel, who has introduced several improvements into the original Werdermann lamp, the resistance of the contact of carbon is very small, about ·134 of an ohm; hence it will take several of them, 7 or 8 (or perhaps 10), arranged in series in the same circuit, to equal the resistance of the electric arc. To work these lamps of low resistance only a low electro-motive force is required, and so the result is attained by driving a small resistance dynamo-electric machine at moderately low speed; or by placing a considerable number of lamps in series, so as to make their combined resistance equal to or greater than the internal resistance of the machine. Thus a Gramme machine, revolving at the rate of 1200 revolutions a minute, giving an electro-motive force of about 130 volts, will give a current of 50 webers through about 10 lamps in series. But this current gives an illumination of 320 candles in each lamp, so that with this current we get an illumination of 3200 candles in 10 lights. Now, the energy expended to produce this rate of revolution in a Gramme machine is about 9 or 10 h.p. Hence the Werdermann, or the Joel lamp, gives at least two lights of 160 candles each for each h.p. of energy expended.

Mr. Alex. Siemens lays down, in his paper on "Electric Lighting," that 4 lbs. of coal, costing 15s. a ton, will produce 1 h.p. of energy per hour, and that, if a steam-engine be employed to produce an electric light of 6000-candles power, the cost would be 5d. per hour. If the same illumination be produced by 15 lights of 400 candles each, the cost would be 2s. 1d., or five times as much. Hence the cost for a 400-candle light would be at the rate of about $1\frac{2}{3}$d. per hour.

Now, by comparison, we may get some idea of the price of the electric light when obtained by means of the Werdermann or Joel lamp. If we compare the light obtained by the Joel or Werdermann lamp

with that from the 400-candle light from the arc, we get about 320—or, say, 300—candle power in the Joel light for 800-candle power in the other. Hence the price of the electric light from a Joel lamp should be at the rate of 6½d. per hour for a 600-candle power light.

Now, according to Mr. Alex. Siemens' estimate for gas, the price of gas would be at the rate of about 5⅘d.—or nearly 6d.—per hour for the same light. In other words, the cost of the electric light from the Joel lamp would be nearly the same as gas at the rate of 4s. per 1000 cubic feet.

In estimating the candle-power of lamps it is usual to place the photometer on the same level with the lamp, so that the surface is illuminated by the rays proceeding horizontally from the lamp. Now, in all lamps, whether Werdermann or arc lights, which are fed by a continuous current machine, the current passes from the positive carbon to the negative always in the same direction; and in the arc lights, the upper positive carbon becomes worn away into a hollow; hence a portion of this carbon obstructs the light, and the greatest intensity of light is not in a horizontal direction, but downwards, at an angle of about 60° below the horizontal. The illumination in this direction is about three times—or even more than three times—the illumination in the same horizontal plane with the arc; hence, when it is said, in the report of the Glasgow tests, that a dynamo-machine, at 1200 revolutions per minute, will give a light of 2060 candles, for an expenditure of 4 h.p.—the light being measured horizontally—we see that the illumination, in a direction inclined downwards at an angle of 60° below the horizon, would be 6500 candles for 4 h.p. or at least 1625 candles per h.p. This will also explain why lights fed from continuous-current machines should be placed at a considerable height above the area to be illuminated. This, combined with the fact that it is far more economical to produce one very powerful light by means of a large machine, than several smaller lights to illuminate the same area to the same degree, will explain why Dr. Siemens is erecting his large lamps at so great a height, for the trials of electric lights which we shall shortly have an opportunity of seeing in the city.

Sub-division of the Electric Current.

The next point to which I propose to draw your attention this evening is the sub-division of the electric current.

It will be simplest to regard first the case where there is a battery of given electro-motive force. In this case, according to Ohm's law,

$$E = C(R + r),$$

where E is the electro-motive force, C the current, R the resistance of the battery, and r the external resistance. If the poles of the battery be joined by two separate resistances, r_1 and r_2,

$$\text{then } E = C\left(R + \frac{r_1 r_2}{r_1 + r_2}\right).$$

If the resistance of each branch is equal to r, and if C_1 be the current in each,

$$\text{then } E = C(R + r) = 2 C_1 \left(R + \frac{r}{2}\right).$$

Let $E = 100$ volts, $R = 1$ ohm, and $r = 100$ ohms,

$$\text{then } 100 = C(1 + 100) = 101 C,$$
$$\text{and } 101 = 2 C_1 (1 + 50) = 102 C_1.$$

Hence nearly the same current flows in each branch as when there is only one wire. If there are 10 branches instead of 2 branches, and if C_x be the current in each,

$$\text{then } 100 = C_x (1 + 10) = 110 C_x,$$

i. e., the current in each branch is $\frac{100}{110}$ instead of $\frac{100}{102}$. If there are 50 branches, and C_y be the current in each,

$$\text{then } 100 = C_y (1 + 2) = 150 C_y,$$

thus the current in each is $\frac{100}{150}$ or $\frac{2}{3}$, and the heating or glowing effect is $\frac{4}{9}$ of it value with only one branch.

Now, if with 50 branches in multiple arc, we diminish the external resistance of each branch so as to get the same current as at first through each branch,

$$\text{then } E = C(R + r) \text{ at first,}$$
$$\text{and } E = 50\ C\left(R + \frac{r_1}{50}\right) \text{ with 50 branches.}$$
$$\text{So that } (R + r) = 50 R + r_1,$$
$$\text{Or } r - r_1 = 49 R.$$

Hence with $R = 1$ and $r = 100$ ohms $r - r_1 = 49$ and the length left has a resistance of 51 ohms, the heating of each of these is $\frac{51}{100}$, or one half of what it was with only one branch. Hence the glowing heat or light from such a resistance will be greater than from the unshortened wire, with the weaker current through it. In this case we get 50 circuits of 51 ohms each, so arranged that the heating effect in each circuit is ·51, or about one-half of what it was at first. Hence

the amount of heat radiated from each is one half of what it was at first. But there are 50 such circuits, therefore the total heat radiated is 25 times as much as it was with only one branch.

If the resistance of the battery and connecting wires is considerable, then we see that the addition of every additional branch circuit takes away greatly from the amount of heat radiated from each branch, so that this plan of sub-division by separate circuits can only be adopted with success when the internal resistance is small as compared with the external resistance. We see, then, that with small internal resistance there is great gain in heating, and, therefore, in light-giving power, by arranging branch parallel circuits in multiple arc; but when the resistance of the battery and leading wires is considerable, the advantage of this arrangement is small, and very little sub-division is admissible.

Incandescent Lamps.

Now, let us consider the case of currents produced by means of dynamo-electric machines, in which the electro-motive force is not constant in the same machine for the same speed, but depends upon the resistance of the circuit. An electro-motive force of 100 volts produces a current of one weber through a resistance of 100 ohms, and Mr. Swan tells us that this current, through a lamp of that resistance, gives a 60-power candle light. Now, if we reduce the length of the carbon filament in the lamp without altering the current, we reduce the illuminating power in the same ratio. Suppose we take it as four-fifths of the length, *i. e.*, its resistance is then 80 ohms, and we shall get a 48-candle power light from the same current (one weber), *i. e.*, with an electro-motive force of 80 volts.

With two such lamps in series we shall get two 48-candle power lights, with an electro-motive force of 160 volts, sending a current of one weber through them, *i. e.*, the two lamps should give out a light of six gas-burners of 16-candle power each, and should be sufficient to illuminate a drawing-room in many of our London houses.

If we consider now how we are to produce this current, we find that a Bürgin machine, by the expenditure of 6 h.p., will send a current of 24 webers through an external resistance of about 7 ohms, giving an electro-motive force of 160 volts. If then we take two lamps in series, *i. e.*, 160 ohms, and arrange 24 distinct series, we shall get a combined resistance of $\frac{160}{24}$, or about 7 ohms, allowing for the resistance of connecting wires, and there will be a current of 1 weber through each cir-

cuit, *i. e.*, this machine should give us 48 lights each of 48-candle power. With a resistance of 50 ohms in each lamp, the number of lamps which may be supplied from the same machine will be double this number. If we reduce our electro-motive force from 100 volts to 80 volts, with the same length of carbon in the lamp, then we reduce the current from 1 weber to $\frac{8}{10}$ of a weber. This in the same resistance will reduce the illuminating power from 60 candles to a light of about 40-candle power, instead of a light of 48-candle power. Hence, with a given electro-motive force, more light is obtained, and, therefore, greater economy is effected by shortening the length of the carbon in the lamp, rather than by diminishing the current through the same length of carbon. Hence, the best results will be obtained in incandescent lamps by sending through them as strong a current as they will safely stand, and making the length of carbon such that the dynamo-machine employed will send such a current through them.

Take another case: Suppose we have one lamp of 75 ohms resistance (*i. e.*, about 45-candle power). A Gramme machine or a Siemens' medium-sized machine will give an electro-motive force of 100 volts, and a current of about 25 webers, at the rate of 100 revolutions a minute, through an external resistance of about 3 ohms. Hence, if we have 25 lamps in separate branch circuits, or in multiple arc, we get 1 weber through each from such a machine, and get a light, according to Mr. Swan, of 45-candle power from each. Hence, such a machine will give us about 1125-candle power illumination. The energy expended would be about 5 or 6 h.p., so that the illumination would be about 200 candles per h.p.

We have seen above that, with the Siemens' alternate current machine, a 400-candle light requires about half a horse power; so that 1 h.p. will supply two lights of 400-candle power, from an alternate current machine at the rate of 10d. for 3 hours. The same illumination can be obtained from gas at 2s. for 3 hours. Now, two-thirds of this cost is for the supply of carbon, which becomes burnt in in the arc. Hence, without this consumption of carbon, the expense per h.p. is only $\frac{1}{9}$ of 1d. per hour. Applying this to the case of incandescent lamps, in which our carbons do not wear out, we see that by a proper arrangement of the lamps we may get a 200-candle power light at the rate of $\frac{1}{9}$ths of 1d. per hour.

Now, Mr. Alex. Siemens also states, in his paper, that at the rate

of 3s. 6d. per 1000 feet, the same illumination cannot be obtained from gas at less than 2d. per hour. Hence, allowing $\frac{8}{9}$ of 1d. an hour for the breakage of incandescent lamps, the cost of light by gas and by incandescent electric lamps would be nearly the same.

If we allow that only a light of 40-candle power, instead of 60-candle power, can be produced at this rate, still the incandescent light cannot be regarded as an expensive light.

Now, in the absence of any actual determination, let us assume the same law to hold in the Brush system as in the Siemens or the Gramme system. In the Brush system a current of 10 webers is sent through an internal resistance of 10 ohms, and an external resistance of 70 ohms. Now, in the Siemens machine, when the external resistance is seven times the internal resistance, the current is only $\frac{1}{60}$th part of its value when the external and internal resistances are equal, or $\frac{1}{40}$ of its value when the external is double the internal resistance. The drawback to this arrangement would be that one-third of the total work expended would be lost in heating the machine.

Taking the Brush machine as worked at present, the difference of potential for each of 16 lamps in circuit is about 40 volts. Hence total difference of potential of 16 lamps = about 640 volts. With an external resistance of 70 ohms there is a current of 10 webers. Hence, if we arrange incandescent lamps in 10 series, so as to get a resistance of 70 ohms, we shall get 1 weber through each series. Put, then, 7 lamps, each of 100 ohms resistance, in each series, and we shall get 70 lamps from a Brush machine. These 70 lamps are each of 60-candle power, and all are worked by an expenditure of 16 h.p. Hence the candle power is 4200 candles from 16 h.p., or 262·5 candle power per h.p. If the lamps of this resistance are only heated, so as to give a light of 30-candle power each, then the candle power per h.p. will have to be reduced.

Thus we have seen that it is possible to sub-divide the electric current in such a way as greatly to increase the amount of illumination which may be obtained by means of a dynamo-electric machine, especially when the light is accomplished by the incandescent system of Swan, Lane-Fox, or Edison.

The earliest attempt to obtain light by incandescence in a vacuum was made by King, in 1843, who applied continuous metallic and carbon conductors, and heated them by an electric current in a Torricellian vacuum. He was followed in 1848 by Staite, who used an

iridium and platinum wire, and enveloped the holder in glass or some other non-conductor. In 1872, Konn employed graphite, and rendered it incandescent in an atmosphere of nitrogen, in which there was no wasting away of the carbon. The same principles have been followed, but with greater promise of success, in the more recent attempts at producing illumination by means of incandescence. The earlier attempts failed, either (1) because of the impossibility of preventing the consumption of the carbon or other material, in consequence of the minute traces of air, which it was impossible to get rid of with the means of exhaustion which were then known; or (2) because of the presence of other gases, such as hydrogen, which exists occluded in platinum and in other substances. It is only quite lately, since our power of obtaining a vacuum has been so greatly extended, and since we have learnt so much about high vacua from the labors of Mr. Crookes, that Mr. Swan and Mr. Lane-Fox have succeeded in obtaining vacua from which all the air and occluded hydrogen are exhausted, so that their carbon filaments and platinum wire connections remain without being destroyed, even when a current of electricity strong enough to make them give out a brilliant incandescent light has been continuously passing through them for months together. Through the kindness of Mr. Swan, and of my friend and former pupil, Mr. Lane-Fox, I am able to show you this evening how well they have succeeded in producing a brilliant, and yet a steady and pleasant incandescent light. This is a triumph which many have sought in vain, and which could not have been attained except by combining together the results of investigations which have been recently carried on in several branches of physics.

I cannot conclude this course of lectures without giving my especial thanks to Mr. H. Trueman Wood, who has given me very valuable assistance, by helping me to bring together a large collection of electrical apparatus, in illustration of the interesting subject which I have had the honor to bring before you.

St. Gothard Tunnel.—The triple concentric vault of the tunnel of the St. Gothard, which was built in the sandy stratum below Andermatt, has been completed and promises to remain as firm as the other parts of the gallery. There is a reasonable hope that engineering skill has triumphed over a difficulty which was at first thought insurmountable.—*Les Mondes.* C.

WEIGHING THE SUN BY A SOAP BUBBLE.

By Pliny Earle Chase, LL.D.

In answer to some inquiries for a fuller explanation of the method of weighing the Sun by a soap bubble,* the following note is submitted to the readers of the Journal of the Franklin Institute.

Naumann ("Handbuch der Chemie," p. 289–90) gives six estimates for the combining energy (Bildungswärme) of a water-molecule, ranging between 67616 calories (Andrews) and 69584 calories (Hess). The mean of the six estimates is 68886 calories, representing a projectile energy, against terrestrial gravitation, of $\frac{68886 \times 1389{\cdot}6}{5280} = 18129{\cdot}55$ miles. As 9 pounds of gas are lifted by 1 pound of combustible, this energy would be sufficient to lift the water vapor $\frac{1}{9}$ of 18129·55 = 2014·394 miles.

At the moment of explosion the equilibrium which usually exists between the gravitation of the particles towards the sun, towards the earth and towards each other, is suddenly and violently disturbed. During the restoration of equilibrium there are simultaneous tendencies to the production of orbital velocities about the sun, about the earth and about centres of oscillation.

The explosive force proceeds radially in all directions from the centre, so that the particles are subjected to cones of force, introducing oscillations which may be represented by a synchronous conical pendulum of $\frac{1}{4}$ the height, or 503·599 miles.

In seeking equilibrium the particles tend toward their own centre of gravity at $\frac{1}{2}$ this height, and also, on account of resistance at the earth's surface, towards the centre of linear oscillation, at $\frac{2}{3}$ of the height. Earth's action on the centre of gravity of the mass produces a secondary centre of oscillation, in which the primary centre of oscillation acts as a point of suspension, and the centre of gravity as a pendulum extremity of wave propagation. This secondary centre of oscillation is at $[\frac{1}{2} + \frac{1}{3}$ of $(\frac{2}{3} - \frac{1}{2}) =] \frac{5}{6}$ of 503·599 = 299·777 miles, which represents the mean *vis viva* of oscillatory projection, relatively

* See article "Radio-dynamics," in this Journal, July, 1881.

to earth, the *vis viva* relatively to sun being represented by earth's semi-axis major.

Let $r = 3962{\cdot}8$ miles = earth's semi-diameter; nr = earth's semi-axis major; $t_0 = 1$ year = 31558149 seconds; $t_1 = 2\pi\sqrt{\frac{r}{g}} = 5073{\cdot}6$ seconds = time of satellite revolution at earth's surface; m_0 = sun's mass; m_1 = earth's mass; $h = 279{\cdot}777$ miles. Then Kepler's third law and Herschel's principle of forced vibrations give

$$\left(\frac{nr}{r}\right)^3 : \left(\frac{t_0}{t_1}\right)^2 :: m_0 : m_1 :: nr : h$$

Solving the proportion, we find

$$m_0 = 331{,}574\ m_1$$
$$nr = 92{,}767{,}000 \text{ miles.}$$

Five years after I published my deduction of the above ratio between the *vis viva* of wave propagation and the *vis viva* of the oscillating particles, §, Maxwell published the same ratio in the *Philosophical Magazine* for June, 1877, p. 453, but without stating how he had found it. I have enquired for his method in quarters where I supposed it might be obtained, but I cannot find that he left any record of it.

Struve's constant of aberration gives 497·827 seconds for the time in which light would traverse earth's semi-axis major. Dividing the above value of nr by 497·827 we get 186,344 miles for the velocity of light.

Griscom's Electromotor.—A French writer compares this motor to one of those which have been devised by Deprez, and calls attention to three effects of induction: 1. The inverse effect which results from the magnetization of the iron; 2. That which results from the successive inversions of the polarization of the central nucleus, which Du Moncel has called currents of polar introversion; 3. That which results from the passage of the magnet before the coils, which is dynamic and is of the same character as the one which is developed in the Siemens machine. The last two currents are direct and prolonged during the whole continuance of the motion; the first is instantaneous. When the electro-magnet begins to move the induced inverse current is injurious, but as it does not last the demagnetization is not sufficient to change the attractive impulsion.—*La Lumière Electrique.* C.

ON THE NEW METAL ACTINIUM.

By Dr. T. L. Phipson, F.C.S., etc.

Since the publication of my two notes in the *Chemical News*, vol. xliii, p. 283 and vol. xliv, p. 73, I have made a great number of experiments with the view of isolating the new substance to which the white zinc pigment owes its remarkable property of darkening in the sunlight, returning to its white state in the dark, and not being affected in this manner under a sheet of glass.

These experiments have at last proved successful, and a very short note to that effect was communicated, about a fortnight ago, to the Acadèmie des Sciences and another to the British Association on Monday, September 5th. I will now describe the process by which I have isolated the oxide and the sulphide of the new metal in a state of tolerable purity. Perhaps this process may be improved hereafter, but it is not very complicated, though it has required an enormous number of experiments to arrive at it. First, one word as to the manner in which the pigment found in commerce is prepared. Ordinary zinc scrap is dissolved in sulphuric acid and a considerable excess of zinc is left in the solution in order to keep out iron, lead, arsenic and other metals. The liquid is drawn off and then precipitated by a solution of sulphide of barium; the precipitate is dried, calcined, raked whilst hot into cold water, dried again, ground, etc. It then consists of sulphide of zinc, oxide of zinc and sulphate of baryta, with *minute* quantities of iron, lead, arsenic, manganese, etc.

The manner in which I have obtained the oxide and sulphide of actinium from this pigment is as follows, and the process will doubtless serve for the treatment of other substances in which the presence of the new metal may be detected:

About 15 grammes of the finely pulverized pigment are left for 24 hours in dilute acetic acid (strongest acetic acid and water equal parts), and the mixture well stirred or shaken occasionally. This takes out most of the iron, manganese, magnesia, lime and *oxide* of zinc. The residue, after being washed, is treated exactly in the same manner with dilute hydrochloric acid (acid 8 parts, water 92 parts), with the

object of completing the action of the acetic acid. The residue, well washed, is then heated with strong hydrochloric acid, to which a little nitric acid is added from time to time. The solution of the chlorides thus obtained is filtered to separate free sulphur and the insoluble sulphate of baryta, any remaining sulphur in suspension after filtration being oxidized by a few crystals of chlorate of potash. To this solution of chlorides, somewhat diluted, a considerable excess of caustic soda is added and the solution heated. The zinc oxide goes into solution and the white oxide of actinium remains; the latter is received upon a filter, washed, dissolved in hydrochloric acid and the solution again treated with excess of caustic soda. (These operations may be repeated two or three times, in order to eliminate the zinc oxide as completely as possible.) Finally, the oxide of actinium, still impure, is washed on a filter and dissolved in a considerable excess of hydrochloric acid. The solution is neutralized by ammonia, and then the latter is added in excess. All but a little iron oxide remains dissolved (if not, dissolve again in HCl and add ammonia in excess, which, this time, will only precipitate the iron). The iron oxide is separated by the filter, and to the filtrate sulphide of ammonium is added, which throws down the sulphide of actinium as a bulky pale canary-yellow precipitate, the color of which is best seen when it is received on a filter.

Oxide of Actinium.—The hydrate as precipitated by soda or ammonia forms a bulky white precipitate, more gelatinous than oxide of zinc; unlike the latter, it is only very slightly soluble in caustic soda, even when the liquid is heated; it is not precipitated by ammonia from solutions containing ammoniacal salts. It is a permanent white, with a slight tinge of salmon color when seen in bulk, and it does not change color when exposed to the air, as oxide of manganese does, neither does it appear to be affected by the direct rays of the sun. It is readily soluble in acids. The anhydrous oxide is not volatile nor decomposed by heat. It has a pale fawn-colored tint.

Sulphide of Actinium.—The hydrate as precipitated from its neutral or alkaline solutions by sulphide of ammonium is a bulky pale canary-yellow precipitate, insoluble in excess of sulphide of ammonium, scarcely at all soluble in acetic acid, readily soluble in mineral acids even when they are diluted. When exposed to the direct rays of the sun it darkens and becomes quite black in about twenty min-

utes, except in those places where it is protected by a piece of ordinary window glass.

The quantity of actinium sulphide obtained from the white pigment amounts to no less than about 4 per cent. This yield is enormous. The presence of this new element in zinc will account, probably, for the discrepancies noticed in the *equivalent* of this metal as determined by various observers. The new element differs very essentially from manganese, zinc and cadmium, but has, perhaps, some points of similarity with lanthanum. It exists, evidently, in considerable quantities in at least some kinds of commercial zinc. As soon as I shall have written the next number of my *Journal of Medicine*, I intend to pursue these investigations.—*Chemical News.*

Athermanous Photometer.—The industrial progress of electric light increases the desirability of a good photometer, which is easily transportable and does not require delicate manipulations. Unfortunately, all the instruments which have hitherto been invented have the grave defect of being influenced both by light and heat. Raimond Coulon proposes an apparatus which is acted upon by light alone. It is based upon the following principles: 1. In a Crookes' radiometer, if a difference of temperature is produced upon any point of the surface of the glass envelope the wheel ceases to turn, under the influence of light, as long as this difference continues. There is a fixed relation between the value of the angle which one of the palettes makes with the heated or cooled point, the intensity of the luminous ray, and the calorific difference between the disturbed point and the rest of the envelope. 2. The luminous conditions remaining constant, every radiometer of which the temperature is raised turns in such a manner that the bright side of the mica pallette seems to be attracted by the envelope. Every radiometer of which the temperature is lowered turns in an opposite direction; every radiometer of which the temperature is constant remains immovable, so long as it is in obscurity. 4. Every radiometer of a constant temperature turns under the influence of light alone. The inventor soon found that it was necessary to maintain the instrument at a temperature superior to that which is produced by the radiant heat of the luminous sources which are to be measured. Practically, the temperature of boiling water is convenient and sufficient.—*La Lumière Electrique.* C.

Comets of 1811 and 1881.—Dr. Eugene Robert calls attention to some striking resemblances between the agricultural results of these two comet years. In each of them there was a great drought, lasting through the whole summer, and accompanied, in some countries, with violent storms; the harvest was bad in many places, the crop of cereals especially being short; but the grape crop was good, the fruit being well developed and rich in materials for vinous fermentation.—*Les Mondes.* C.

Ramie.—M. Favier, the inventor of a machine for stripping the bark from ramie, has exhibited his process at Avignon, in the presence of a numerous gathering of industrial and agricultural notables. The experiment was entirely satisfactory; the machine instantly broke the rigid stalks, rejected the woody portion, and transformed the bark into straight, fine and silky filaments, thoroughly prepared for spinning and dyeing. This machine seems likely to add great importance to the cultivation of ramie in the southern and central districts, and, perhaps, even in the northern districts of France.—*Les Mondes.* C.

Radiophony by Lamp Black. — Mercadier finds that lamp black is not only the best thermophonic agent, but that it is also susceptible, like selenium, of becoming an electric photophone. He covers one of the faces of his double spiral receivers with the smoke of oil or camphor, taking care to avoid carbonizing the parchment paper which insulates the metallic spirals. These receivers having two faces, one may be selenized and the other smoked, so that experiments may be made with the same current on either face. Receivers with spirals of copper, brass, iron or platinum, when thus smoked, work well; aluminium receivers, which cannot be selenized, are easily smoked, and then operate readily. With such receivers sounds are easily heard which are produced by the radiations of the sun, of the electric or oxyhydrogen light, or even of a gas jet. Some of the inventor's experiments seem to show that the origin of the sounds is not thermal, in the ordinary sense, but the phenomenon is simply photophonic or actinophonic. The resistance of a lamp black receiver diminishes when the temperature increases. The variation is well represented by a straight line. It is very small, the mean coefficient of variation per degree being less than one-fourth of one per cent.—*Compt. Rend.* C.

Origin of Cometary Light and Heat.—Emile Delaurier advances the hypothesis that the great rapidity of cometary motion causes the æthereal matter to vibrate and transforms it into light and heat. He expands his hypothesis so as to account for all the variations of form which the great comets undergo, for the apparent solar repulsion and for the curvature of the tail.—*Les Mondes.* C.

Application of Electricity to the Study of Rapid Phenomena.—Marcel Deprez has contrived a register which gives excellent results in making rapid measurements with the intervention of a single Bunsen cell. He has already succeeded in reducing the time of a double signal to about $\frac{1}{1600}$ of a second. It is not necessary to have the current closed longer than $\frac{1}{40000}$ of a second in order to give the signals.—*Lumière Electrique.* C.

Comet Spectrum.—The French observers find many striking resemblances between the spectra of Gould's and Coggia's comets. The nucleus gives a continuous spectrum, without bands or lines. The nebulosity near the nucleus shows three bands, one very bright, the others faint. The band spectrum is so much like that of alcohol that Thollon considers them identical. The violet alcohol band is not seen, but its absence seems to be owing to atmospheric absorption. There is little doubt of the presence of carbon in some of its compounds.—*Comptes Rendus.* C.

Explosion of Bubbles.—Plateau has published some new experiments upon thin liquid films. One of the most interesting is one which furnishes conclusive evidence of the contraction which the bubble undergoes during its rapid destruction. He filled with tobacco smoke a bubble of glyceric liquid of about 11 centimetres (4·3 in.) in diameter and laid it upon a ring of 4 centimetres; waiting until the blue color of the summit showed that it was upon the point of bursting he pierced the summit with a metallic wire. The mass of smoke was thrown vertically for about a decimetre above the bubble and then spread horizontally, like an umbrella, and continued to mount more slowly while diffusing itself into the air. The experiment was repeated several times with the same result.—*Acad. Roy. de Belge.* C.

New Method of Telegraphing.—An officer of the French army has invented a telegraph with which some interesting experiments have been recently made at the Trocadéro. It consists simply in reading large letters of silvered zinc, fixed upon a blackened surface. He claims that with an ordinary telescope he can read such despatches, under favorable circumstances, at a distance of 80 kilometres (49·7 miles).—*Les Mondes.* C.

Synthesis by the Electrolysis of Organic Acids.—Bartoli and Paparogli find that in the electrolysis of dilute acids the graphite or carbon electrodes waste away and partly dissolve; with potash the liquid becomes colored; barytes gives $BaO.CO_2$. With a hundred Bunsen elements carbon electrodes become gradually conical towards the lower extremity in distilled water, but they wear away regularly in dilute sulphuric and oxalic acids and in solutions of potash or soda. Mellic and hydromellic acids are found in the solutions. Other solutions give similar effects with the carbons.—*Les Mondes.* C.

Spectroscopic Grouping.—C. L. Ciamician gives a spectrum of the second order for boron, composed of lines in five groups. He groups the elements in the order

B, Al, C, Si	N, P, As, Sb	O, S, Se, Fe
Fl, Cl, Br. I, Na, K, Rb, Cs		Mg, Ca, St, Ba

He thinks that in each group the elements are formed of a fundamental material combined with numerous atoms of oxygen. The atomic weights, which are calculated according to his rules, differ notably from those which are commonly given.—*Ber. Wien. Akad.* C.

Cutting Glass and Porcelain.—In endeavoring to drill glass and porcelain, or to cut them in accordance with marked lines, there are many difficulties which often lead to failure. Messrs. Richter & Co., of Chemnitz, cover disks of soft metal of 15 to 25 millimetres (5·5 to 9·8 in.) diameter with diamond dust, and mount them upon an arbor moving with great velocity, so as to cut glass or porcelain, in a few seconds, according to any given design. By means of cylinders, constructed on the same principle, round holes can be drilled with great rapidity. The wear of the instruments is imperceptible.—*Les Mondes.* C.

Action at a Distance.—An important contribution to photo-dynamics and general radio-dynamics has been made by George Helm, of Dresden. He investigates the movements of molecules in the æther, the exchange of energy between molecules and the external æther. gravitation, magnetics, electrical and dielectic currents and conduction, and the di-electric condition. His results corroborate many of the formulas of Faraday, Maxwell and Chase.—*Wied. Ann.* C.

Height of the Atmosphere.—Dr. A. Kerber has estimated the height of the atmosphere from the phenomena of refraction. By two different methods he obtains heights of 189 and 192·6 kilometres (117·4 and 119·7 miles).—*Wied. Annal.*

[Some of the observations upon meteors and auroras have led to the conclusion that the atmosphere reaches a height of more than 500 miles. Laplace's limit of synchronous rotation would allow a possible height of more than 26,000 miles. The theory of Fresnel and Grove, that the luminiferous æther is only a very tenuous atmosphere, would make the portion which belongs to the earth of the same height as Laplace's limit. C.]

Effects of Lightning upon Trees near Telegraph Wires.—Arago has examined the causes of the dangers to which persons may be exposed in the neighborhood of telegraph wires during a thunder storm. Montigny has lately investigated the danger to trees in similar circumstances. In the neighborhood of Dinant there are nearly 500 poplars on the north side of the road, with a telegraphic wire passing very near them. Eighty-one of these trees, or a sixth part of the whole number, have been struck by lightning upon the south side of the trunk almost always at the point nearest the wire. The trees of the other row, which is at some distance from the wire, are very rarely struck by the electric fluid. The wounds made by the lightning are of three kinds: 1. The bark is torn and shivered upon the side towards the wire over a narrow portion of the trunk; 2. The thunder bolt traces upon the tree a furrow more or less broad which begins at the height of the wire and descends the trunk to the ground, most often in a straight line, but sometimes in a spiral; 3. The wounds have a peculiar oval form, and the edges of the bark are colored a clear brown.—*Acad. Roy. de Belge.* C.

Telegraphy in Paris.—The total number of city telegrams in Paris, in 1880, was 969,177, which yielded a total income of 579,-857.47 francs ($115,971.49). The reduction of the tariff has been found, by various experiments, not only immediately to increase the circulation of telegrams, but also to enlarge the dividends. The number of despatches has nearly tripled within the last four years.—*Bull. de la Soc. d'Encour.* C.

Living and Dead Protoplasm.—O. Loew finds from his investigations that living protoplasm possesses the property, in a high degree, of reducing metals from their solutions, but that this reducing power is lost by death. Hence it may be concluded that the mysterious phenomena of life are connected with peculiar groupings of atoms, possessed of special motions which are analogous to those of the aldehyde group.—*Pflüger's Archive.* C.

Destruction of Rocks under Water.—Major Lauer, an Austrian engineer, has made some experiments at Krems on the Danube which have excited great attention. He placed a cylinder loaded with dynamite upon the surface of the rock, and exploded it by an electric current. However small the quantity above the cylinder, the rock was crushed into bits so small that they were easily swept away by the current. The process is said to reduce the expense of removing submerged rocks 40 per cent.—*Les Mondes.* C.

Rotation of the Plane of Polarization. — Leo Grunmach reports an investigation which was based upon the supposed identity of the radiations of heat and light, and which leads him to the following conclusions: 1. In solid as well as in fluid diathermanous bodies there is an electro-magnetic rotation of the polarization plane of radiant heat in the direction in which the current flows through the spirals. 2. The magnitude of this rotation is very different for different substances, and appears to be nearly proportional to the index of refraction. 3. In the direct influence of a galvanic current upon the diathermanous bodies the amount of rotation is proportional to the intensity of the current. 4. When a diathermanous body is placed between the poles of an electro-magnet the rotation is proportional to the magnetic force. 5. The amount of rotation increases with the length of the stratum through which the rays pass, but the ratio of increase is not well established.—*Wied. Annal.* C.

Underground Life in England.—The proposed tunnel under the English Channel has led to some statistical inquiries which have shown that the number of persons in Great Britain who are engaged in underground employment is 378,151. The length of the galleries in which their labors are carried on is not less than 58,744 miles. The greatest depth of the channel is 180 feet and the lowest part of the tunnel will not be over 200 feet below the surface. The greatest depth of the coal mines is about 2800 feet and the least is about 300 feet. The channel tunnel will only form about one-thirtieth of one per cent. of the total subterranean excavations.—*Les Mondes.* C.

Conclusions of the Electrical Congress.—The electrical congress at Paris has adopted the following conclusions: 1. The fundamental unit is the centimetre, gramme, second (C. G. S.); 2. The *Ohm* and *Volt* will retain their present values, 10^9 for the ohm and 10^8 for the volt; 3. The unit of resistance (*Ohm*) will be represented by a column of mercury having a section of a square millimetre and the temperature of 0°C.; 4. An international commission will determine by new experiments the length of the above column of mercury which will represent the value of the Ohm; 5. The current produced by a Volt in an Ohm is to be called *Ampère;* 6. A Coulomb is the quantity of electricity which would enable an Ampère to give a Coulomb per second; 7. A *Farad* is the capacity in which a Coulomb gives a Volt.—*La Lumière Electrique.* C.

Book Notices.

A Study of Various Sources of Sugar; Sugar-cane, Sorghums, Sugar-beet, Maple, Watermelons, etc. By Lewis S. Ware, Member of Am. Chem. Soc., etc. Philadelphia. 8vo. H. C. Baird & Co. 1881.

This thick brochure, containing some extensive tables, shows much knowledge of the subject treated, and acute investigation; and it well deserves the attention of all who desire to ascertain the fullest material progress of the sugar interests of the United States. The main intention of Mr. Ware is to advocate the extensive manufacture of

beet-root sugar, which has—as to this staple—rendered France independent of all countries, and which is widely and successfully introduced throughout Europe. This book shows, *inter alia*, that in a field of operations of equal extent the beet would have advantages over cane sugar. The cost of cultivation of 100 acres of sugar-cane and of beet-roots would average nearly the same (about $50 each per acre); but while the net profit on the *manufacture* of cane sugar would be at the rate of $20 per acre, the net profit on beet sugar would be $46 per acre. One-third only of such a large difference ought to prove a wonderful stimulus to the introduction of beet sugar.

The value—including custom dues—of the *foreign* sugar consumed in the United States during the years 1877, '78 and '79 is shown to average $109,000,000 annually, and for 1880 the amount was $118,749,573. All this vast yearly expenditure might go to our own agriculturists, refiners, and their employés. As sugar from beets has been proved to be equal to that made from cane, the relative economy of manufacture must largely influence the future introduction of beet culture. To this end, however, the dissemination of proper information is needful, that farmers may cultivate with confidence, and refiners contract freely for the production.

Another intention of this book is to prove how illusory and unreliable were the favorable reports made by the Agricultural Bureau of the United States respecting sorghum cane and its saccharine qualities.

Mr. Ware's book is a timely contribution to the technical literature of this age of many transitions. S. H. N.

Modern Milling. Being the Substance of Two Addresses delivered at the Franklin Institute by Robert Grimshaw, Ph.D. 8vo. Philadelphia: H. C. Baird & Co. 1881.

This work does not pretend to enter deeply into the multitudinous subjects of flour mills, flouring machinery, and the various processes. It gives, however, an excellent idea, in popular form, of the most modern plans for producing flour, and the requisite improved machinery. A thorough treatise on flouring mills and machinery is much needed, none such, we believe, existing in any language. This is not

surprising if it be considered how the flouring processes and machinery have been changing during the past ten years; it would have been almost impossible for any writer to keep pace with the improvements.

We understand that Mr. Grimshaw has now in press a large and complete work on this important industry. If such had not been the case, the present book would have been disappointing; but its contents fully agree with the statements of the title-page, and as an introductory volume it is good. The first portion treats of the form and various envelopes of the wheat berry; the ideal mode of splitting it in gradual reduction; also descriptions, with illustrations, of smutters, separators, heaters, and other grain-preparing machinery. Several modern arrangements of buhrs are shown, their ventilation, etc., followed by an excellent description of the machines for purifying middlings, such as have been in use for some years past. A good feature in the book is a concise summing up of the various changes in processes, machinery, customs, size of buildings, etc., which have occurred during the past ten years.

High *roller* milling is the subject of the second lecture, and in it the various forms of rollers, their grooving and mode of action, is clearly explained. At the close of the volume there are several large plates, showing the interiors of typical modern flouring mills. S. H. N.

PROGRESSIVE AGRICULTURE. By C. L. Ingersoll. The Relation of Science to Agriculture. By Harvey W. Wiley. 8vo. Indianapolis. 1880.

These two essays upon very important subjects have been reprinted in pamphlet form from the Proceedings of the Indiana State Board of Agriculture. The authors have the chairs of Agriculture and Chemistry in the Purdue University, and the subjects are treated in an able way, Prof. Ingersoll insisting that progressive agriculture demands for further progress a more thorough education of the masses in the underlying principles of the science and their best application, also to abandon the hap-hazard style of farming, for in order to succeed the farmer must systematize his labor, the rotation of crops, etc., to place his productions at the least cost, remembering that in unity of thought, purpose and action lies the road to success.

In Prof. Wiley's contribution he takes up the subject of the devel-

opment of agriculture, as it is only in this way that an idea can be formed of the processes which have been and are most active in determining agricultural progress, confessing that the advance for two thousand years has been evidently small, and hardly any record of it preserved, the great chemist Liebig being the first to promulgate the principles of modern scientific agriculture. A *resumé* is then given of the scientific views held with reference to soils, crops and fertilizers, the influence of humus, etc. Next to the soil, climate and the weather are claimed as the most important factors which enter into the agricultural problem, and a fitting compliment is paid to the work of the signal service for the remarkable accuracy of many of its predictions. The paper closes with short accounts of the part biology plays in the study of the domestic animals and the laws of their variation and improvement; the intimate relations botany and entomology have to agriculture, and last, but not least, chemistry, the science which has always been regarded as bearing the most intimate relation to the culture of the soil, and yet, candor compels him to own, as not being the most important as far as the practical work of the farm is concerned, a knowledge of the soil and its constituents not being able to solve every problem, and much of the disappointment at the results of chemical methods and of the ill will it has received arising from this cause. Chemistry alone will not do everything for the farm, but when its work is properly combined with the work of of other sciences, it first acquires its true value. I. N.

The Preparation and Use of Cements and Glue. By John Phin. 12mo. New York: The Industrial Publication Co. 1881.

In the preparation of this little book, we are assured in the preface, that the utmost care has been taken to secure accuracy. When we consider the number of utterly worthless recipes which have been published with the sanction of names which stand high in the mechanical world, it is no wonder that even the best collections have admitted useless formulæ to their pages, and the compiler adds that he believes most of the formulæ here given will do all that is claimed for them, and wherever he has had any doubt upon this point it has been intimated, the reliability of many of them having been tested by personal experience.

Such information is of great value, and to have it collected in a neat and handy little volume, without searching for it in the innumerable journals, cyclopædias, etc., will be appreciated by the busy workman and amateur mechanic, into whose hands this work is likely to fall. One hundred and seventy-seven formulæ in all are given, alphabetically arranged for ready reference, while the general rules for the use of cements, with which the book opens, seem mest excellent.

I. N.

THE ELEMENTS OF PLANE ANALYTIC GEOMETRY. By George R. Briggs. 12mo. New York: John Wiley. 1881.

Newton so well established his principles of conic sections that there has since remained but little place in that branch for modern authors. New examples and explanations may be given by them, but the methods and the results remain unaltered.

We bslieve that too little attention has hitherto been accorded in school text-books to the *Loci*, which is the most important and useful of all special applications of mathematical principles. Knowing the conditions of a moving body, its law of motion, its path through space or on a plane may be determined by an algebraical formula whose co-ordinates satisfy an equation known as its *Loci*.

This subject has been briefly but intelligently handled in Mr. Briggs' little book, and we are convinced it must be a valuable assistance to students of the Freshman class of Harvard College, as well as to adults who are lovers of mathematics in its elementary branches.

L. S. W.

Franklin Institute.

HALL OF THE INSTITUTE, Nov. 16th, 1881.

The stated meeting was called to order at 8 o'clock P.M., the President, Mr. William P. Tatham, in the chair.

There were present 102 members and 45 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers and announced that at the last meeting of the Board 26 persons were

elected members of the Institute; also that, in accordance with the recommendation of the Committee on Science and the Arts, they had awarded the Elliot-Cresson Gold Medal to William Woodnut Griscom for his invention of the Electric Motor.

Prof. Robert E. Rogers, chairman of the Committee on the "Dangers Incident to Electric Lighting," said that he regretted to be obliged to say that, while his committee had held several meetings, they had not been able to prepare an absolute and complete report to be presented at this meeting. In view, however, of the apprehensions and anxiety of the community, which looks to the Franklin Institute for guidance on this subject, the committee desired permission to give its report to the press and public as soon as it should be completed. "It is due to the Institute," he said, "that the subject should not be trifled with, for it is one of great gravity, and the report of the committee should be well considered. The committee would pledge itself to present its report in such a way as to furnish full information to the public and yet not commit the Institute to its views until action could be taken on it."

Mr. Orr said that the chairman of the committee evidently took a true view of the importance of the subject committed to its consideration, but he hoped that if the report was to be given to the public before being acted upon by the Institute, that fact would be distinctly stated.

Prof. Rogers said that he proposed to make the committee alone responsible for the views expressed, and not the Institute, until the latter had been given an opportunity to pass upon it.

On motion, the committee was given leave to present its report through the press, as suggested by Prof. Rogers.

The report of the Committee on Fire Escapes (which is printed in full in this number of the JOURNAL) was then read by the Secretary.

Mr. Grimshaw said that he considered the report most excellent and timely, but he wished to enter his individual protest against one or two of the conclusions of the committee. He protested against the endorsement of bridges leading to tower stairways, believing that the bridges were liable to be blocked up by people attempting to escape by such long tubes. He also wished to protest against the recommendation to enclose elevator shafts in brick walls, thus making them flues to carry the products of combustion over the building.

He thought that elevator shafts should not be enclosed. He also called attention to the fact that the words "incombustible" and "fireproof" were not interchangeable, and said that a stairway built of incombustible material as recommended in the report might, nevertheless, be dangerous in case of fire, being crumbled or broken by heat.

Prof. Rogers said that he considered the report admirable; as nearly exhaustive as it could be made, and free from the objection of committing the Institute to any special form of fire escape. It tells frankly the dangers to be met, describes various ways of meeting them, compares their relative merits entirely on general principles and from all the information deduces certain guiding lines of action in legislation and in the construction of fire escapes. He felt so well satisfied with the work of the committee that he offered the following resolution:

Resolved, That the thanks of the Institute be returned to the committee for their able report, and that the Institute adopt it with the provisions and qualifications contained therein.

This was agreed to by a vote which appeared to be unanimous.

Mr. Hugo Bilgram read a paper on his new Odontograph, illustrated by a model showing how it could be used for laying out the teeth of gear wheels. It is based on the fact that if the shape of the teeth of a rack consists of two congruent branches, corresponding points of which meet tangentially in the pitch line, any two gear wheels correctly gearing into this rack will also correctly gear with one another. Briefly described, a template of a tooth, carefully filed so that each side consists of two equal curves meeting exactly in the pitch line, is attached to a bar representing the rack, one edge of which (the pitch line) is carefully straightened. The template is so attached to the bar that a small space is left between them the depth of the tooth. A circular plate (or portion thereof) of a diameter equal to the pitch diameter of the wheel, has fastened to it a piece of sheet metal or card-board on which the tooth is to be marked and which must, therefore, be as large in diameter as the gear wheel. When the wheel is rolled upon the rack, pitch line on pitch line, the sheet metal or card-board of the wheel passes between the template of the rack and the bar to which it is fastened, and the shape of the tooth can be described upon the second template in a number of different positions. The form thus delineated being then cut and filed the second template

is completed. A band of very thin steel, one end of which is fastened to the rack and the other to the wheel plate, may serve as a means to prevent slipping. It is advisable to have the second template extend to the centre of the plate, that its centre may be marked to insure radial position of the teeth. Mr. Bilgram also explained at length how this principle could be applied to machines for cutting gear wheels.

The President of the Institute described his Improved Dynamometer, a large model of which was on exhibition and photographic diagrams of three forms of it projected upon the screen. It aims, by a simple and novel device, to measure the power transmitted without absorbing it. A description of the apparatus is published in the JOURNAL for November, with illustrations.

The Secretary then presented his report. Among the novelties shown was Chamberlain's Safety Attachment for Elevators, designed, in case of the breaking of an elevator rope, to instantly stop the car from falling before it has acquired any momentum. The rope is attached to a yielding draw bar or cross bar, connected by links with a rock shaft under the car. Locking cams act against vertical chains of rods, which are firmly attached at their upper and lower ends to rigid parts of the elevator well and pass through grooved recesses in the elevator car. When in use the cams are turned so as to allow the car to move freely up or down; but the moment the rope breaks, thus removing strain on the cross bar, springs on the rock shaft are freed and operating upon the shaft turn the cams into a position where they are at once engaged in the locking recesses. The inventor claims that this action is instantaneous, and that there is consequently no opportunity for the car to acquire momentum.

A balanced valve for steam engines, the invention of Mr. William L. Dewart, Jr., was described, which has been in use at the Philadelphia and Reading Railroad shops on Hamilton street for the past year. The object is to lessen pressure of the valve upon the valve seat, thus diminishing friction and effecting a saving in the cost of a given amount of power. In this valve there is a superimposed balance plate connected with the body of the valve by a ball and socket joint, the plate and valve being so constructed that they compensate for any inequality in the valve seat. The inventor claims that with this balanced valve there can be no choking nor back pressure, nor

can there be a "cushion" formed between the valve and the sides of the chest.

Two of Holman's new Projecting Lanterns, made by Zentmayer for Mr. Henry Bower and Mr. George H. Perkins, were exhibited. They are intended to be used in the lecture hall, school room and the home, to show more than one person at a time the revelations of the microscope, and also to serve as first-class microscopes for scientific investigation, and as lanterns for the exhibition of ordinary slides. Mr. Holman stated that with one of these instruments the little animal *amœba* had been for the first time shown to more than one person at a time, this being done in a large lecture hall in illustration of one of his lectures.

A number of fire escapes were shown, among them being a truck ladder invented by Henry C. Bender, which can be taken to a burning building by the firemen and raised to any story against or independently of the wall. The ladder is made in links so as to roll up on a cylinder. The turning of a crank causes it to extend and rise from the truck as a rigid ladder. The truck itself can be shifted laterally while the ladder is extended.

One of Crookes' Ruby Tubes, imported by Queen & Co., was exhibited by the Secretary; also a model of Grier's Street Railway, in which the cars are propelled by an endless wire rope (operated from a central station), to which the cars are attached by a clutch passing through a narrow opening in the street.

Mr. Cooper said he would like to bring before the Institute the question of holding an exhibition of small machines this winter, especially of such as are of general interest, including electric lights and other electrical apparatus. He had noticed that Industrial Hall on Broad street had been recently enlarged, and he thought that the Institute could hold a creditable and useful exhibition there of the kind suggested.

The President inquired whether Mr. Cooper had any motion to make and, when told he had not, said that if Mr. Cooper would present his suggestion to the Committee on Exhibitions he had no doubt it would receive attention.

On motion, the Institute adjourned.

ISAAC NORRIS, M.D., *Secretary.*